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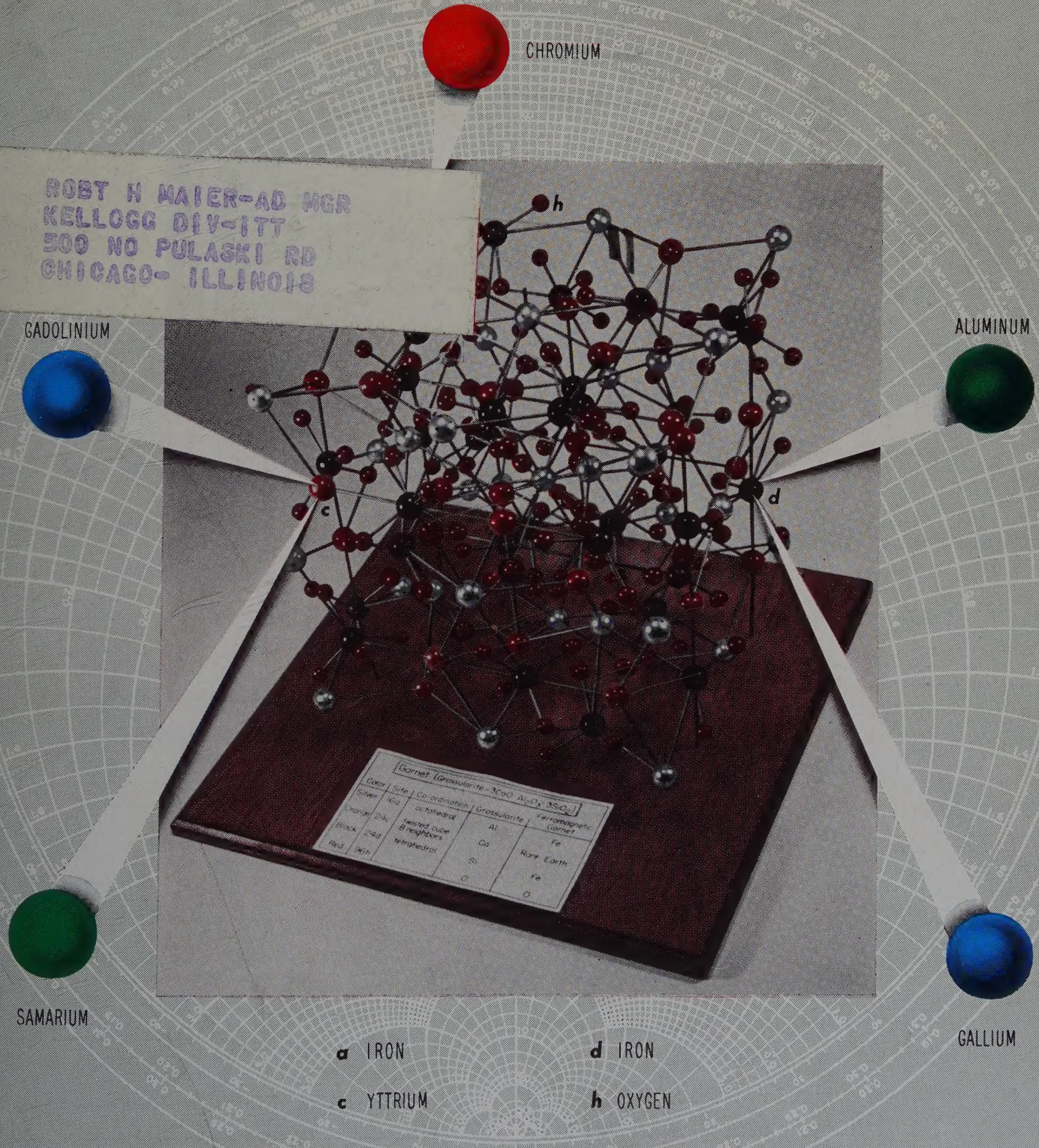
- Harrison & Hodges — Microwave Properties of Polycrystalline Hybrid Garnets
- Ko — Temperature Concepts In Modern Radio
- Strandberg — Linear, Complex-Reflection Coefficient Bridge
- Jenness, Barr & Bernella — Centrifugal Forming of Paraboloidal Antennas

the microwave journal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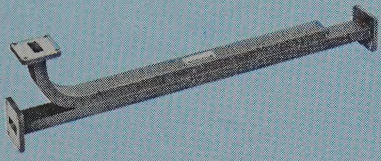
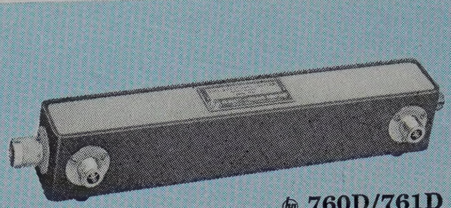
In This Issue . . . **Microwave Properties of Polycrystalline Hybrid Garnets**

TESTED *waveguide and coaxial equipment*



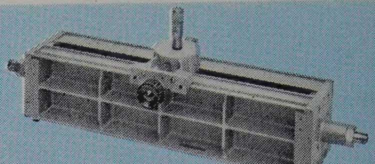
hp 752 Multi-Hole Coupler

Precision directional couplers provide coupling factors of 3, 10 or 20 db. Coupling accuracy ± 0.4 db or 0.7 db. Directivity better than 40 db full range, SWR less than 1:1 (752A), 1:05 (752C/D). Cover frequencies 2.6 to 40 GC. $100.00 to $375.00.



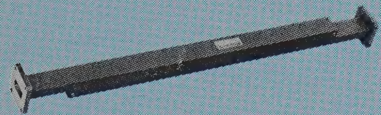
hp 760D/761D Dual Directional Couplers

Ideal for reflectometer systems, these coaxial couplers are flat to ± 0.5 db over 4-to-1 frequency range. Directivity is 35 db (760D) and 30 db (761D). Feature high power capacity, low insertion loss and SWR. hp 760D, 250 MC to 1 GC, $200.00; hp 761D, 1 to 4 GC, $185.00.



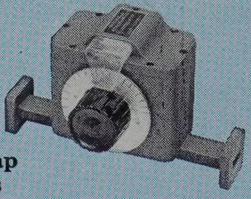
hp 870A/872A Slide Screw Tuners

For waveguide, coaxial (872A shown) applications. Probe position, penetration sets up reflection cancelling existing reflection. Lead screw or micrometer varies probe insertion for 870A Tuners, 2.6 to 40 GC, $125.00 to $300.00. Micrometer drive varies insertion on 872A, 500 MC to 4 GC, $525.00.



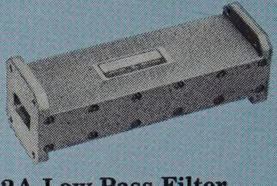
hp 372 Precision Attenuators

Rugged, broadband fixed attenuators retaining precise calibration regardless of humidity, temperature or time. Invariant attenuation assured by permanent, "multi-hole coupler" joining of two waveguides. 10 and 20 db models, 2.6 to 18.0 GC. $110.00 to $400.00.



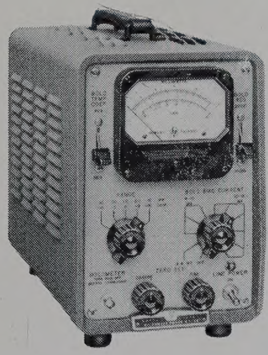
hp 375A Variable Flap Attenuators

Simple, convenient for adjusting waveguide power or isolating source and load. Max. SWR less than 1.15 full range; attenuation variable 0 to 20 db, dissipates average powers up to 0.5 or 1 watt. S through R bands, 2.6 to 40.0 GC. $90.00 to $190.00.



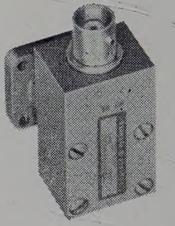
hp 362A Low Pass Filter

Compact models increase SWR measurement accuracy by suppressing harmonics; feature low insertion loss, broad stop band. 8.2 to 40.0 GC (includes N-band model). $325.00 to $385.00.



hp 430C Microwave Power Meter
hp 476A/477B/485 Mounts

hp 430C reads rf power direct in dbm or mw, requires no calculations. Covers 2.6 to 40.0 GC, operates with hp 476A, 477B, 485 bolometer, thermistor or detector mounts; also with hp 487 Broadband Waveguide Thermistor Mounts (see alongside). hp 430C, (cabinet), $250.00; hp 430CR, (rack mount), $255.00. hp *476A Universal Bolometer Mount,* 10 to 1,000 MC without tuning, $85.00. hp *477B Coaxial Thermistor Mount,* 10 MC to 10 GC without tuning, $75.00. hp *485 Detector Mounts* available in three basic series: S485A 2.60 to 3.95 GC, no tuning; 485B, 3.95 to 12.4 GC; 485D, 2.6 to 8.2 GC. 485 models, $75.00 to $185.00.



hp 487 Waveguide Thermistor Mounts

Models covering 2.6 to 40.0 GC. Each covers full range of guide; no tuning, SWR 1.35 to 2.0. 10 mw max power. Uses permanently installed 100 ohm negative coefficient thermistor; 18.0 to 40 GC models use 200 ohm thermistor. $75.00 to $225.00.

hp 810/815B Slotted Sections

hp 810B Slotted Sections. hp 810B, for 809B carriage, flanged, waveguide section with accurately machined slot. Slot tapered at ends to minimize reflection. 3.95 to 18.0 GC. $90.00 to $125.00.

hp S810A. Complete slotted section assembly including probe carriage. In 2.6 to 3.95 GC (S-band) size only. $450.00.

hp 815B Slotted Sections. For mounting in 814B carriage. Available in two bands, 18.0 to 40.0 GC. Accurately machined; easy interchange, precise positioning. $265.00.

hp 806B Coaxial Slotted Section. 3 - 12 GC, fits 809B, Type N connectors. $200.00.

hp 805C/D Slotted Lines

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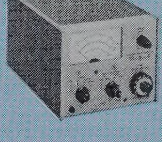
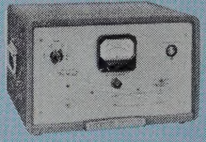
hp 415B/C Standing Wave Indicators



hp 415B operates with all hp waveguide and coaxial slotted sections, gives readings in SWR or db. Low noise level, 0.1 μv full scale sensitivity, 60 db calib. attenuator. $200.00 (cabinet), $205.00 (rack). *New* hp *415C* (pictured) offers similar characteristics but is transistorized, incorporates revolutionary four-times expansion of readings at any point on any scale. Price on request.



hp 416A Ratio Meter

Displays ratio between two signals, irrespective of common amplitude variations. Especially useful for swept frequency measurement of VSWR, reflection coefficient, gain, insertion loss and other microwave parameters. Calibrated in VSWR, % reflection, db. See offer for hp Application Note 42 elsewhere in this advertisement. $550.00 (cabinet), $535.00 (rack).

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Recent Progress in Microwave Radio Communications

A Cooled, Negative Conductance, Degenerate Parametric Amplifier

Methods of Using Pure Noble Gas in Gas Switching Tubes

Compact, Multihole, Waveguide Directional Couplers

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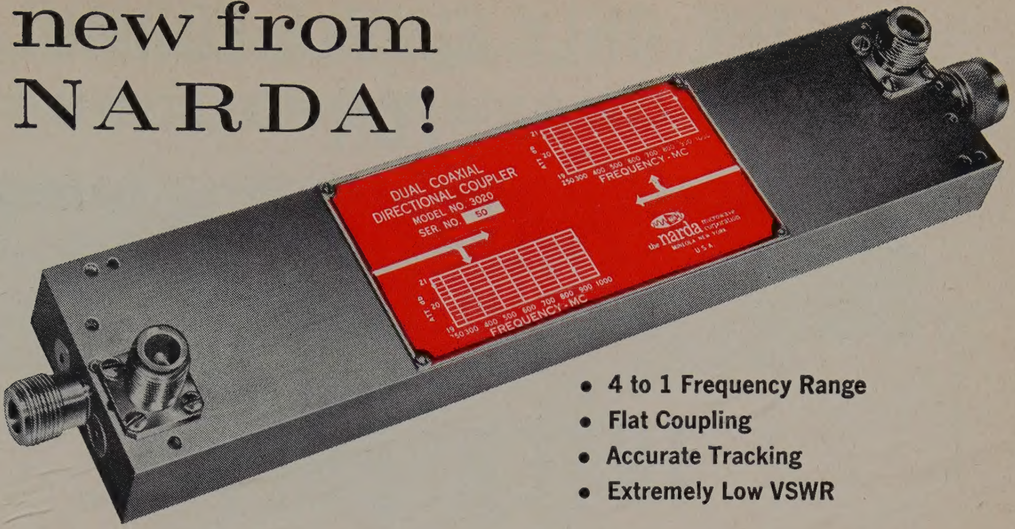

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Specifically designed for REFLECTOMETER applications!

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- What's more, each model covers two full octaves; each features extremely accurate tracking (0.3 db maximum change in difference between forward and reverse coupling over the band); each has a power rating of 100 watts CW, 10 kw peak. Check the table for full specifications—and compare with any other units available.

- These are just two examples of the complete line of unusually fine microwave and UHF instrumentation available from Narda. Write today for your free copy of our newest catalog. Address: Dept. MJ-61-4.

SPECIFICATIONS	MODEL 3020	MODEL 3022
Frequency	250 to 1000 mc	1000 to 4000 mc
Directivity	35db min	30db min
Coupling—both arms	20db nominal	20db nominal
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Max VSWR—main line	1.05	1.10
Max VSWR—secondary lines	1.10	1.15
Power Rating	100W cw 10kw peak	100W cw 10kw peak
Tracking	0.3db total	0.3db total
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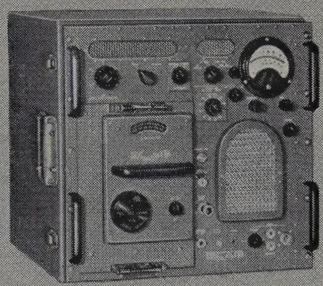

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LOW FREQUENCY • Model NF-105	HIGH FREQUENCY • Model NF-112	ENTIRE FREQUENCY RANGE
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Through years of hard field use Model NF-105 has acquired an outstanding reputation as a noise and field intensity meter for the frequency range from 150 kilocycles to 1000 megacycles. The versatility of this instrument has now been expanded through the introduction of a new tuning unit extending its coverage down to 14 kilocycles. What is more, this unique measuring equipment has been joined by Model NF-112 which covers the frequency range from 1000 to 10,000 megacycles. The same simplicity, accuracy and speed of operation and reliability of performance which made Model NF-105 so successful have been designed into Model NF-112. Each instrument uses an impulse generator as its calibrator; each combines in one basic unit the components common to all frequency ranges, including the power supply, calibrator, attenuators and metering circuits. All frequency determining components and circuits are contained in plug-in tuning units. Model NF-112, incidentally, uses one single antenna for the entire range from 1000 to 10,000 megacycles. **You save considerably in SIZE, WEIGHT and COST by letting these two instruments do your entire interference measuring job from 14 KC all the way up to 10,000 MC.**

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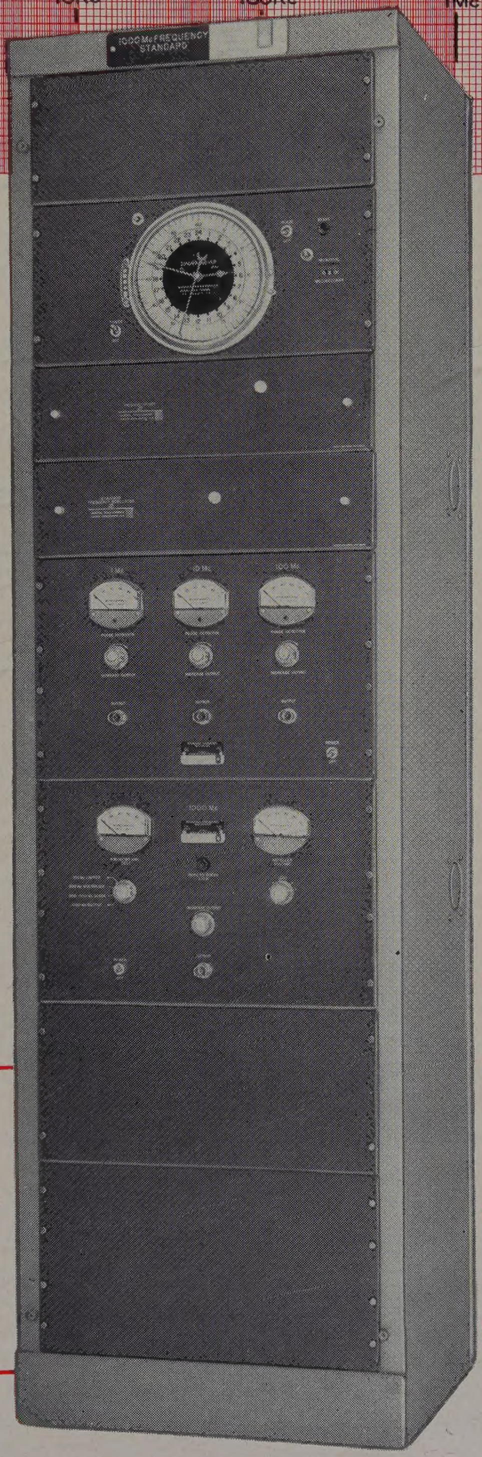

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MICROVIEWS OF THE MONTH

53 ▶ MICROWAVE PROPERTIES OF POLYCRYSTALLINE HYBRID GARNETS

Gordon R. Harrison and L. R. Hodges, Jr.

Microwave engineers performing research and development on microwave solid state devices have need for ferrimagnetic materials with a wide range of properties. It is very useful for application purposes to have materials in which the microwave properties may be independently controlled. This paper describes 'molecular engineering" techniques for independently controlling and varying the microwave properties of garnet materials. The compositions investigated include solid solutions of yttrium-iron garnet with gadolinium-iron, samarium-iron, yttrium-aluminum, yttrium-gallium, and yttrium-chromium garnet.

60 ▶ TEMPERATURE CONCEPTS IN MODERN RADIO

H. C. Ko

During recent years the term, temperature, has been used in a variety of new ways in modern radio electronic literatures. A few examples are the antenna temperature, the sky temperature, the noise temperature, the electron temperature, the excitation temperature, the spin temperature, and the negative temperature. Origins of the new temperature concepts are discussed. It is shown how these different temperature concepts are related to each other and to the classical concept of thermodynamical temperature. For a system in thermodynamic equilibrium these temperatures have the same value and the temperature has a definite and unique meaning. When the concepts of temperature are extended to systems not in thermodynamical equilibrium, the temperatures are in general quite different. Each temperature then becomes a convenient parameter for describing a certain physical state of the system.

66 ▶ LINEAR, COMPLEX-REFLECTION COEFFICIENT BRIDGE

M. W. P. Strandberg

Some advantages of oscilloscope presentation of complex-reflection coefficient data for microwave component design are discussed. A microwave phase sensitive detector is described and the application of the device to measurement of the Q of the cavity is presented. The microwave method whereby both real and imaginary parts of the reflection coefficient can be obtained contemporaneously is described. Some applications of the device using both linear circuits such as resonant cavities and nonlinear circuits such as crystal detectors and varactors is indicated. Applicability of these techniques to electron magnetic resonance apparatus of high sensitivity is also sketched. The aim of this discussion is to indicate how an apparatus of low accuracy but high data gathering capability can be simply constructed.

74 ▶ CENTRIFUGAL FORMING OF PARABOLOIDAL ANTENNAS

James R. Jenness Jr., Franklin W. Barr, David M. Bernella

It has been known for many years that the surface of a liquid in a container rotating about a vertical axis stabilizes in the form of a paraboloid of revolution about this axis. HRB-Singer became interested and has been working on further development of the technique since 1956. Precision paraboloidal antennas up to 4 ft. in diameter have been made, and centrifugally-formed molds are now available, making possible the production of precision antennas by conventional techniques.

OUR COVER

Shown is the crystal structure of yttrium iron garnet and an artist's conception of "molecular engineering" or "ionic substitution" into the structure for controlling the microwave properties of the material. The article by Gordon R. Harrison and L. R. Hodges, Jr. appears on page 53.

Photograph of garnet structure courtesy of Harvard University
Layout by Archie Poole of Sperry Microwave Electronics

JUNE 1961
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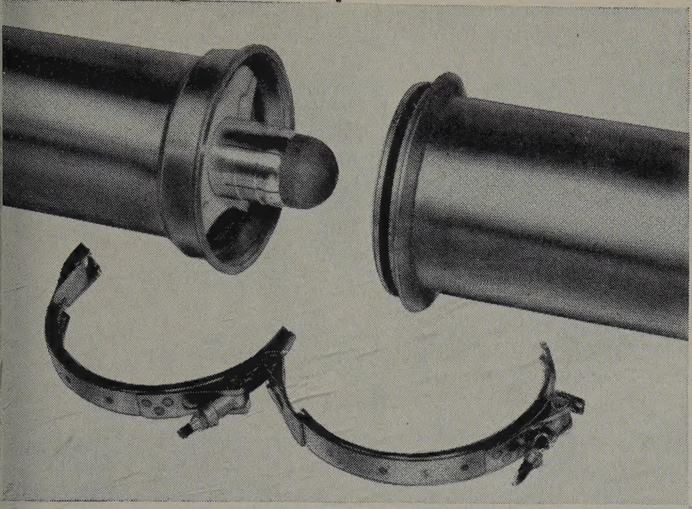
In This Issue Microwave Properties of Polycrystalline Hybrid Garnets

proven in use

DIELECTRIC Rigid Transmission Lines Satisfy Every Performance Requirement



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Special sizes: 9, 10, 12, 16 inches

Any length up to 30 feet

All standard impedances from 25 to 200 ohms

Copper or aluminum outer conductors

oth DIELECTRIC Lines—Type 40 Quick-Clamp d Type 70 EIA Bolted-Flange are:

- **Engineered to exhibit low VSWR, small attenuation of power**
- **Designed for high average and high peak power transmission**
- **Engineered to provide minimum r-f leakage at connections**
- **Notable for their proven low-noise connections**

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usually flexible in application and installation, DIELEC-RIC'S Type 40 Line offers such specific advantages as:

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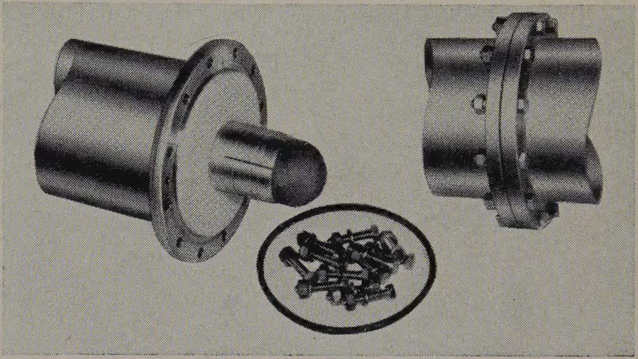
YPE 70 EIA (RETMA) LINE

hen specifications stipulate an EIA (RETMA) bolted-nge line, DIELECTRIC Type 70 offers the same elec-ical properties as the Type 40 line. Positioning of line ctions during installation is made accurate by alignment ns. An O-ring placed between the flanges is provided r gas sealing.



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"LOOK FOR THE SIMPLE SOLUTION FIRST"

There was a time when one form of story telling was primarily concerned with some moral or motto the story teller was trying to illustrate. Although this technique is still used, it is not carried on with the same obvious approach as even a few years ago.

The loss is not in the stories themselves but the points they tried to make.

Aesop was probably the most famous exponent of this ancient technique. Some of his lessons are useful even today.

My only reason for mentioning it is that there is a motto, or rule, if you prefer, that could stand some good exposure. The rule states, "Look for the Simple Solution first."

For many engineers, microwave included, this rule should be as familiar as the sour grapes or rolling stone episodes. Unfortunately, it is not.

A tremendous amount of time and energy is wasted by people who are unaware that this is a rule that should be applied in solving engineering problems as well as the problems of daily existence.

Too many things are overdesigned because no effort was made to look for the simple solution first. Too often problems go unsolved because the tendency is to look only for a complicated approach.

This does not mean that every problem will lend itself to a simple solution. However, if one in five succumb to this approach, it is an invaluable technique.

It is probably true that younger engineers tend to overlook this approach more than their seniors. One reason may be their desire to demonstrate a wealth of knowledge on all sorts of highly complicated subjects. Another factor is the almost natural tendency for people to make things appear even more complicated than they really are. This becomes most apparent in the choice of vocabulary.

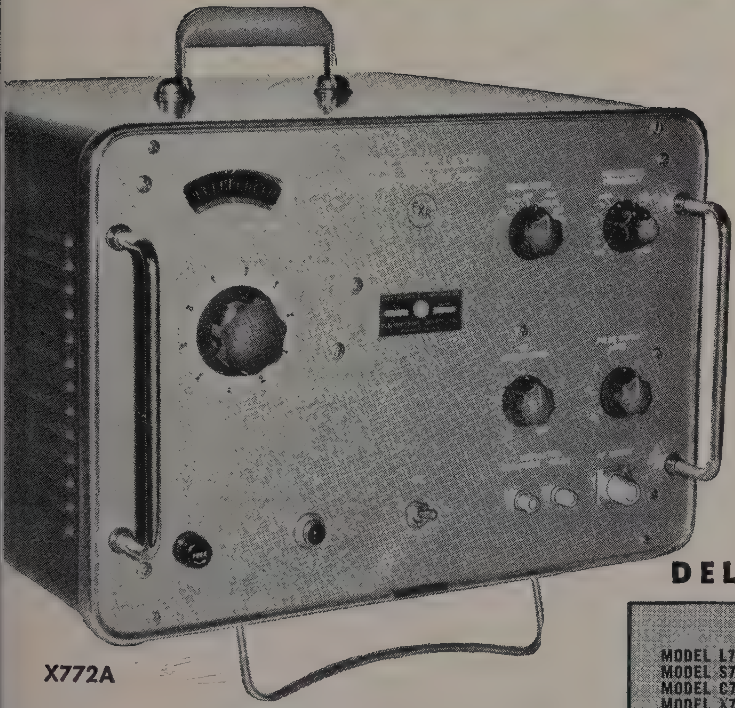
Vocabulary is the secret code which enables one engineer to communicate with another engineer without allowing a stranger to completely interpret the conversation. However, once the translation to simple basic language is made, the code broken, the logic and simplicity of science in any field becomes apparent and the simple solution is easier to find.

Before closing this topic, there is another rule that proves useful in all sorts of situations. It is, "Look for the simple explanation first." This has to do with problems that have already been solved. Although it has value in the laboratory, this rule is found to be of greater use in solving brain teasers. Try it.

Ted Saad

SIGNAL SOURCES

direct reading, self contained...


X772A

4 MODELS COVER RANGES FROM 0.95 KMC TO 11.0 KMC

MODULATED AND CW OUTPUT

AMPLE POWER FOR NORMAL REQUIREMENTS

SERIES 772 SIGNAL SOURCES

- Single control tuning
- ±1% frequency accuracy
- Pulse or square wave modulation, internal or external
- 10 mw to 100 mw max. CW power output
- Regulated internal power supply

Truly unique in the industry, the FXR family of signal sources provides full coverage from 0.95 KMC through 11.0 KMC. Power output is more than ample for most test requirements. The sources provide for the use of internal or external modulation, either pulse or square wave, or external FM. Design features include an internal, regulated power supply and frequency tuning dial accuracy of ±1% throughout the range. This frequency tuning accuracy is always assured by automatic variation of the klystron reflector voltage simultaneous with positioning of a broadband, non-contacting tuning plunger within the oscillator cavity. Each model is a compact self-contained unit ready for laboratory or field use.

DELIVERY FROM STOCK

	FREQUENCY RANGES	PRICE
MODEL L772A MODEL S772A MODEL C772A MODEL X772A	0.95 to 2.0 KMC 1.9 to 4.0 KMC 3.95 to 8.2 KMC 7.0 to 11.0 KMC	$1340. $1340. $1340. $1340.
FREQUENCY ACCURACY	±1%, all models	
POWER OUTPUT	10 mw to 100 mw max CW output power variable by front panel control through use of an internal level-set attenuator	
MODULATED OUTPUTS	Internal: CW, pulse or square wave External: Pulse, square wave or FM	
EXTERNAL MODULATION REQUIREMENTS	Pulse: positive pulse of 30 v. amplitude across 100 K ohms. Pulse width from 1 microsecond to square wave Reflector: sine wave or sawtooth FM, sensitivity from 100 to 200 kc/v	
CONNECTORS	RF Output—Type N jack External Pulse—Type BNC jack Reflector Modulation—Type BNC jack	
POWER REQUIREMENTS	115/230 v. AC, 50 or 60 cycles, 150 w.	
DIMENSIONS	11" high x 16" wide x 15" deep	
NET WEIGHT	45 lbs.	

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PRECISION MICROWAVE EQUIPMENT • HIGH-POWER PULSE MODULATORS • HIGH-VOLTAGE POWER SUPPLIES • ELECTRONIC TEST EQUIPMENT

Industry News

RAEMER APPOINTED PHYSICS SPECIALIST

The appointment of Dr. Harold R. Raemer as a physics specialist at the Applied Research Laboratory of Sylvania Electric Products Inc., Waltham, Mass., has been announced by Dr. James E. Storer, acting laboratory director.

In his new capacity, Dr. Raemer will be engaged in a theoretical research program seeking new knowledge on the propagation of very low frequency radio waves. He will also participate in a project involving microwave transmission through ionized gases.

Co-author of several technical reports and articles, Dr. Raemer and Henri Hodara, head of space communications, Hallicrafters Co., Chicago, delivered a paper entitled "Space Communication Problems During Re-entry" before many of the world's leading space scientists at the 11th International Astronautics Congress in Stockholm, Sweden, last August. Another co-author of the paper was Dr. George I. Cohn, professor of electrical engineering at Illinois Institute of Technology.

Prior to joining Sylvania, Dr. Raemer was a staff engineer with Cook Research Laboratories, Chicago, Ill., for five years, and a senior physicist with the Bendix Aviation-Research Laboratories for three years. While at Bendix, he performed work on missile seeker development projects.

—*mwj*—

REDLIEN NAMED CONSULTING ENGINEER

Henry W. Redlien, Jr., has been named consulting engineer at Wheeler Laboratories, Inc., a subsidiary of Hazeltine Corporation, Little Neck, N. Y.

Mr. Redlien has been project supervisor for the development of one of the several NIKE-ZEUS ground antennas under Wheeler Laboratories' subcontract from Bell Telephone Laboratories. He has also worked on microwave components and antennas for the NIKE-AJAX and NIKE-HERCULES tracking radars and microwave guidance equipment for the TITAN missile and various space vehicles. As a result, he is a recognized authority in the field of monopulse theory and practice.

Also named consulting engineer was Peter W. Hannan, best known for his invention of the polarization-twisting Cassegrain antenna.

Messrs. Hannan and Redlien received Masters degrees from the University of Pennsylvania and Stevens Institute of Technology respectively. Both were graduated from Stevens Institute of Technology.

—*mwj*—

CONTRACTS AWARDED FOR FURTHER RADAR DEVELOPMENT

New contracts totaling $2,293,000 were announced recently for further development by Raytheon Company of radars to fire the U. S. Army's Mauler missile accurately, even while its carrier is weaving through battle areas.

The contracts were awarded by Convair/Pomona, Convair Division of General Dynamics, prime contractor for the Mauler program.

Mauler is a new U. S. Army air-defense missile system, designed to destroy short range tactical missiles, as well as high performance aircraft that bomb, strafe, harass or reconnoiter battle area positions. Its unique ability to fire on-the-run makes it ideal for use by fast moving field forces.

Mauler contracts awarded to Raytheon now total $6.9 million. Work under those announced will be performed by Raytheon's Equipment Division at its Wayland, Mass. facility.

—*mwj*—

(Continued on page 12)

Circle Reader Service Card 6 ➧

TALK ABOUT
Sensitivity

TWO ORDERS OF MAGNITUDE SUPERIOR TO ANY INSTRUMENT OF ITS KIND NOW IN PRODUCTION, Microwave Dynamics' new Model 600 is really the "cat's whiskers" in **Microwave Attenuation and Standing Wave Indicator.** Matter of fact, we are proud to state that for the first time in the history of the microwave industry, precision measurement of VSWR and attenuation is now available in a single, low cost instrument.

The Model 600 provides:

- Synchronous phase detector for extremely narrow bandwidth operation at 1000 c/s.
- Two separate meters operated simultaneously. Meter "A" is logarithmic so that a 10 db range is covered with linear db markings. Meter "B" provides two expanded scale indications, 0.5 db and 2 db, over the scale length. All meter readings are normalized and correlated as well as color coded.
- Precision internal attenuators for continuous level setting independent of display meter accuracy and amplifier linearity. Step switches of 10 db (6 steps), 1 db, 0.1 db are provided, with a potentiometer to cover the range of 0 to 0.15 db. The instrument is self-calibrating in that the accuracy of the 1 db step switch is sufficient to permit calibrating and setting all the other step attenuators, as well as the meter scales.

As if these features aren't enough to make any microwave engineer purr, the Model 600 also provides:

- Overload and underload protection for expanded Meter "B".
- Bolometer bias current continuously variable in two ranges from 0.5 to 2.5 ma and 2 to 10 ma dc
- Provision for setting bolometer operating resistance to 200 ohms and measuring corresponding dc bias current.
- Bolometer protection against transients provided
- True constant current bias supply.
- Internal test points for checking attenuator calibration independent of amplifier linearity.
- Front panel provision for checking amplifier linearity.
- Recorder output provided for both meters.

Modular Accessories Available

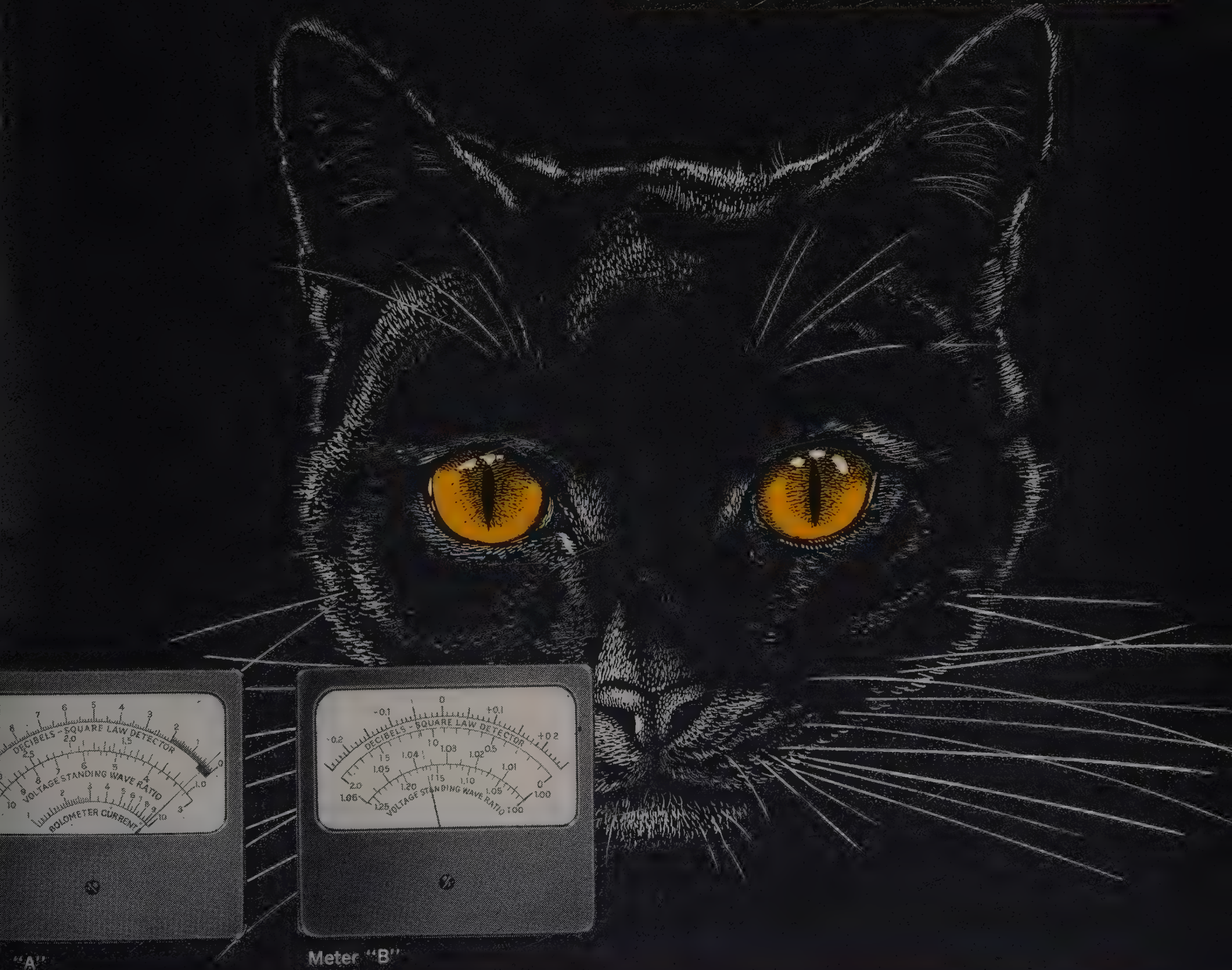
Model 600-1 — Stabilized 1000 c/s Reference Frequency Oscillator
Model 600-2 — Remotely-Operated 6" Expanded Scale Meter.
Model 600-3 — Bolometer Preamplifier for Dual Channel, Null Detection Measurements.

A Symbol of Reliability in the Microwave F
MICROWAV
PLAINVIEW INDUSTR

NOW...ONE indicator measures BOTH

SWR and ATTENUATION

DOWN TO A CAT'S WHISKER


DECIBELS - SQUARE LAW DETECTOR
VOLTAGE STANDING WAVE RATIO
BOLOMETER CURRENT
"A"
DECIBELS - SQUARE LAW DETECTOR
VOLTAGE STANDING WAVE RATIO
Meter "B"

NAMICS CORPORATION a subsidiary of Talley Industries, Inc.

, PLAINVIEW, LONG ISLAND, N. Y. *OVerbrook 1-6811*

Complete information available on request.

THE LINCOLN LABORATORY
Massachusetts Institute of Technology

Lincoln Laboratory is supplementing its staff. The Laboratory is engaged in basic air defense research for the space age. This expanding program is a natural outgrowth of our advanced research and development in the fields of Radio Physics, Radar, Systems Studies, Satellite Surveillance, Computer Technology and Solid State Physics. Senior scientists are invited to join the Laboratory in solving urgent problems of importance to the defense of the United States.

The Laboratory is seeking qualified specialists in:

RADIO PHYSICS and ASTRONOMY
NEW RADAR TECHNIQUES
SOLID STATE PHYSICS and METALLURGY

- **A more complete description of the Laboratory's work will be sent to you upon request.**

Research and Development
LINCOLN LABORATORY
Massachusetts Institute of Technology
BOX 25
LEXINGTON 73, MASSACHUSETTS

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Industry News

(Continued from page 10)

HALLICRAFTERS AWARDED LOGISTICS SUPPORT CONTRACT

The Hallicrafters Co., Chicago, I electronics firm, has been awarded el tronic warfare contracts totalling $9,00 000 by the Logistics Command of U. S. Air Force, Dayton, Ohio, Rob F. Halligan, president, has announced.

These contracts cover logistic supp items for airborne electronic coun measure equipments used by all comb training and development commands the Air Force — equipments develop and produced by Hallicrafters.

Electronic warfare equipments a carried to neutralize enemy radar fenses and to permit United States a craft and missiles to reach their targets.

The Logistics Command, headed Gen. Samuel E. Anderson, was former known as the Air Materiel Command. operates and controls the global logisti networks which support the Air Train ing, Air Defense, Strategic Air, Tactic Air and Systems Commands of the A Force.

— m w j —

LORAL NAMES BRENNER TO DEVELOPMENT POST

Loral Electronics Corp., New Yo N. Y., has announced the appointme of Milton Brenner to the newly creat post of assistant chief engineer, Develo ment.

Mr. Brenner joined Loral in 1960 as special project engineer, Advanced Sy tems. He was previously a departme manager with W. L. Maxson Co. a before that was on the technical staff Sterling Precision Corp. He holds B and MEE degrees from New York U versity.

— m w j —

AGA RECEIVES BEACON CONTRACTS

Aero Geo Astro Corp., Alexandri Va., electronic firm, has received thr beacon contracts, it has been announce by Kenneth L. Nelson, AGA Vi President.

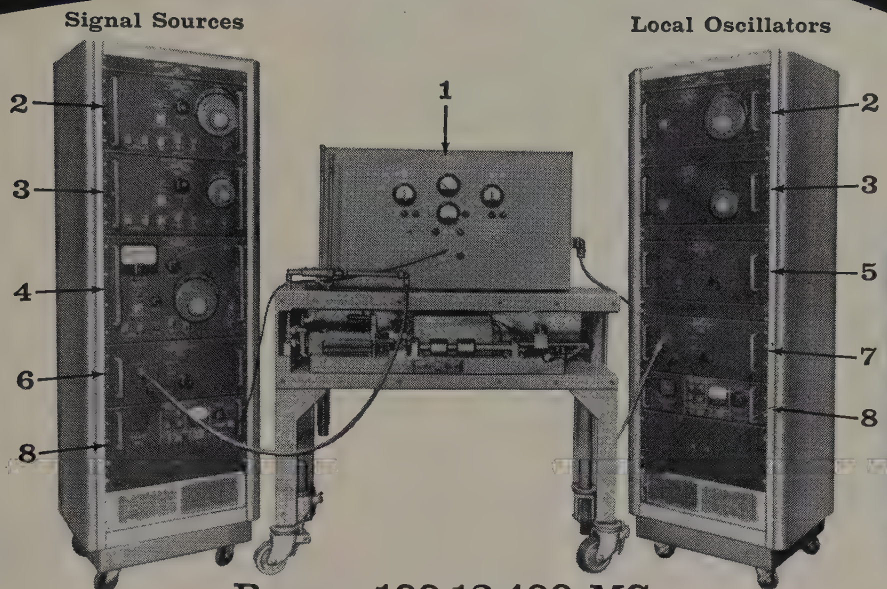
Among the beacons ordered are th AGA X/T X band Radar Beacon f New Mexico University; S Band Cryst Video Beacon for target drones built b the Haynes Corporation, Birmingham Ala.; and Crystal Video C Band Beaco for Oklahoma University for use by th U. S. Air Force in high altitude soundin probe vehicles.

— m w j —

(Continued on page 14)

Complete Attenuation Measuring System

VM-1† by WEINSCHEL



1	VM-1
2	MS-12 50-250 mc
3	MS-13 250-920 mc
4	MS-3 900-2200 mc (self-contained)
5	MS-8 900-2200 mc
6	MS-9V 2100-4200 mc
7	MS-9 2100-4200 mc
8	MO-3 POWER SUPPLY MODULATOR

Range: 100-12,400 MC

Picture shows a complete system for the range 100-4000 MC. Signal sources and local oscillators to 12,400 MC available.

Iakes a 70 DB measurement vith 0.02 DB precision

This is the only complete working system commercially vailable from one source which offers standards labora-ry accuracy over such a great dynamic range. Each omponent is designed for compatability, resulting in ptimum systems performance. This Weinschel system oes perform:

- A 60 db measurement with an accuracy greater than 0.12 db starting with 20 millivolts (—21 dbm)
- A 120 db measurement with accuracy greater than 0.4 db starting with 2 volts (+19 dbm)

aves Time of Skilled Personnel

The VM-1 is **direct reading,** easy to use. No calibra-on curves or correction charts are needed. This **ease of peration** enables normally skilled personnel to perform uch of the work and still save many hours both in tting-up time and in measurement time.

Typical example of time saved for making eight 10 db step measurements of signal generator output attenuator or an external variable attenuator:

	Old Method		Using Weinschel VM-1	
	Time	Personnel Required	Time	Personnel Required
Set-up time for one frequency.	1 day	Highly skilled with experience	15 min.	Normally skilled operator with one week initial training.*
Measurement time	30 min.	Highly skilled with experience	3 min.	No technically skilled operator required.

* Installation and training at customer's laboratory by a Weinschel specialist is included with each system purchased.

Typical Uses of the VM-1

The VM-1 attenuation measurement system is designed for use in **standards laboratories.** It can also be used in **precision testing** on a 100% basis in certain **production** applications where state-of-art accuracies are required (e.g., radar fuzing systems, guidance and satellite communications systems). It is also used in the **calibration** of output attenuators of **signal generators.**

†atent applied for.

For complete information on the VM-1 Attenuation Measuring Systems, call or write the Application Engineering Department, Weinschel Engineering Company.

WEINSCHEL ENGINEERING®

ENSINGTON, MARYLAND
Phone: LOckwood 4-0121
TWX: KENS 446

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accuracy here
means accuracy here

■ The high degree of accuracy required in antennas and radio telescopes demands the finest precision manufacture. For example, assembling massive tetrahedrons like these to within thousandths of an inch requires a "master craftsman" attitude and years of training and experience. ■ Blaw-Knox men have this skill and experience—backed by the finest facilities. ■ Having these facilities and talents available, Blaw-Knox engineers design all types of antennas with maximum efficiency at minimum weight. All designs are determinate. Nothing is left to trial and error. ■ Blaw-Knox has designed and built most of the large antennas now in service . . . fabricates in steel, special alloys, and aluminum . . . designs to fit your needs or builds to your specifications. Complete research, engineering, testing and fabricating facilities are at your disposal. A letter or phone call will get immediate attention. Blaw-Knox Company, Pittsburgh 38, Pennsylvania.

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ANTENNAS

BLAW-KNOX

Blaw-Knox designs and manufactures for America's growth industries: METALS: Rolling Mills • Steel Processing Lines • Rolls • Castings • Open Hearth Specialties • PROCESSING: Process Design, Engineering and Plant Construction Services • Process Equipment and Pressure Piping • CONSTRUCTION: Concrete and Bituminous Paving Machines • Concrete Batching Plants and Forms Gratings • AEROSPACE: Fixed and Steerable Antennas • Radio Telescopes Towers and Special Structures • POWER: Power Plant Specialties and Valves

Circle Reader Service Card 8

Industry News

(Continued from page 12)

WILSON JOINS KANE ENGINEERIN LABS

Dr. Robert N. Wilson has joined Ka Engineering Laboratories, Palo Alto, C as a Theoretical Physicist, according Kirkwood G. Colvin, General Manager

Dr. Wilson's principal work is in area of microwave beam tubes und large signal conditions. He was award his doctorate degree by Stanford U versity.

He has been a Research Assistant Stanford Physics Department, and Hans Laboratories, Stanford; and a consulta to General Electric Microwave Lab atory.

—mwj—

RESDEL APPOINTS BOSCIA

Archie F. Boscia has been named chi engineer of Resdel Engineering Corp Pasadena, Cal. Mr. Boscia's appointment was announced by Resdel President Henry K. Abajian and Alfred J. Siegmeth, vice president.

Resdel specializes in R&D and the manufacture of VHF, UHF equipment with ultra-phase stability.

Mr. Boscia was formerly associate rector of research and development Collins Radio Co., Burbank, Cal. Prior this he was manager of the airborne na gation program at Hoffman Laborator Los Angeles.

As Chief Engineer for Resdel, he w be responsible for directing and superv ing all engineering programs in the fi of VHF, UHF aerospace instrumentati

—mwj—

HUGHES NAMES TRANTHAM TO MANAGER POST

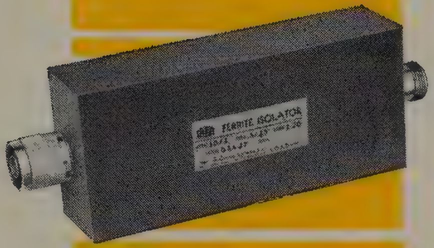
W. E. Trantham, Jr. has been nam manager of operations for the microwa tube division, Hughes Aircraft Co., Culv City, Cal. Dr. Lester M. Field, divisi director, announced that Trantham w take charge of the division's marketi personnel and administrative services partments.

Trantham was formerly military ope tions manager in Washington, D.C., Hughes' components group. He was sponsible for military sales and enginee ing liaison for the semiconduct

(Continued on page 18)

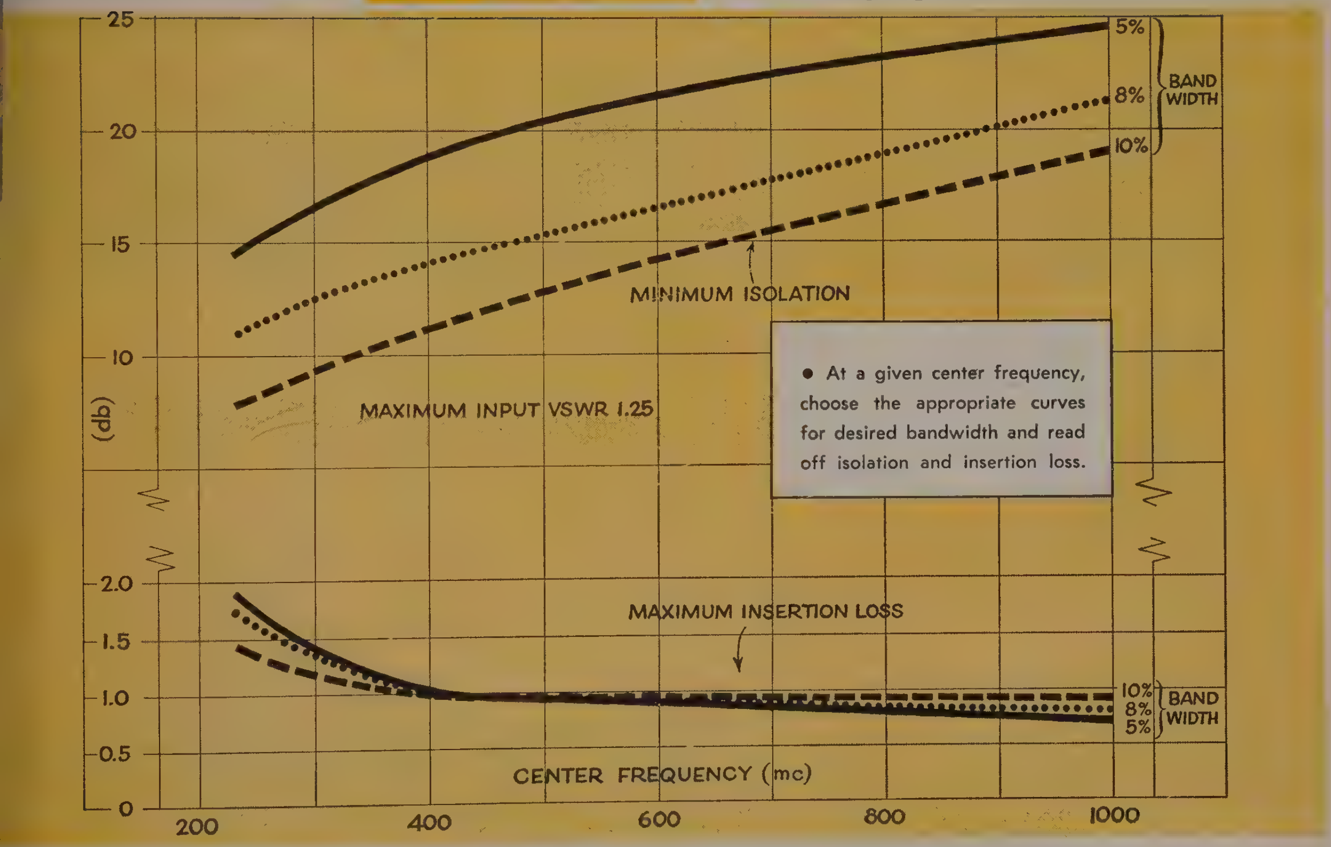
New! SPERRY STRIP TRANSMISSION LINE ISOLATORS

designed to your specs



for Low-frequency Communications and Radar Systems.

- Three Bandwidths — Frequencies from 225mc – 990 mc. Excellent electrical performance. Small size and weight. Relative insensitivity to external magnetic fields.
- Sperry ferrite isolators meet the specifications shown on the curves plotted below and are available for 60 DAY DELIVERY. Within these limits you can determine your own design and operating characteristics. Write for specific details and prices.
- Also, now available from stock — Model D44J7 (frequency 400 - 450 mc) and Model D44P1-5 (frequency 870 - 990 mc). Both units have type N male input and N female output connectors, are 7 37/64″ long, 3″ wide and 1½″ high and weigh 3 pounds.



- At a given center frequency, choose the appropriate curves for desired bandwidth and read off isolation and insertion loss.

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MICROWAVE ELECTRONICS COMPANY,
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icroline Instruments • Radar Test Sets • Systems Instrumentation • ***Solid State Devices and Materials*** *• Microwave Components and Antennas*

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COMPACT, RELIABLE, RUGGED

EG&G CERAMIC-METAL

HYDROGEN THYRATRONS—HYDROGEN DIODES—TRIGGERED SPARK GAPS

These miniaturized hydrogen thyratrons were developed for compact modulator design for missile, airborne, and ground-based applications where size and weight are major considerations. Ruggedly built, they will withstand severe shock, vibration and high temperatures. Write for Data Sheet #040.

THYRATRON RATING CHART

MODEL	e_{py} v.	i_b a	I_b mAdc	I_p Aac	E_f Vac ±7.5%	I_f Aac—max. E_f=6.3v	E_{res} Vac ±7.5%	I_{res} Aac—max. E_{res}=6.3v	P_b	Cathode & Reservoir Warm-Up Time	Dimensions Max. Height-inches	Dimensions Max. Dia.-inches	Wt. lbs.
7621/HY-2	8,000	100	0.1	2.0	6.3	3.5	*	*	2.7×10^9	0.5 min.	2½"	1⅕"	0.13
7620/HY-1	20,000	500	0.5	8.0	6.3	7.5	6.3	4	10×10^9	5 min.	4⅝"	2 5/16"	0.82
7322/1802	25,000	1,500	1.5	47.5	6.3	16	6.3	6	20×10^9	10 min.	5¾"	3⅝"	2.07

*Hydrogen reservoir connected internally across heater-cathode.
Ambient Temperature Limits −65°C to +125°C, 400°C envelope maximum.

THYRATRONS

7621/HY-2
Functionally replaces 1258, 3C45 and most 4C35 glass tubes

7620/HY-1
Functionally replaces 4C35, 5C22 and most 5949 glass tubes

7322/1802
Functionally replaces 5949, 5948 and most 1257 glass tubes

DIODES

HR-2

HR-1

HR-3

High power, high voltage, hydrogen filled diodes designed for use as grid controlled rectifiers, hold-off diodes, inverse clippers and backswing clippers. In spite of their small size and light weight, they are of rugged construction and will withstand severe shock, vibration and high temperatures. Write for Data Sheet #050.

DIODE RATING CHART

	Clipper Diode Ratings				Rectifier Ratings			Heater				Cathode & Reservoir Warm-up Time	Dimensions		Wt.
Type	e_{px} kv	i_b a	I_b Adc	I_p Aac	e_{px} kv	i_b a	I_b Adc	E_f Vac	I_f Iac max.	E_{res} Vac	I_{res} Iac max.	minutes	Max. Height-inches	Max. Dia.-inches	lbs.
HR-2	8.0	9.0	.100	2.0	8.0	1.5	0.25	6.3	3.2	*	*	0.5	2½	1⅕	0.13
HR-1	25.0	250	.125	4.0	20.0	9.0	1.5	5.0	9.5	5.0	3.5	5	4⅝	2 5/16	0.95
HR-3	25.0	500	.500	16.0	25.0	30.0	5.0	6.3	13.0	6.3	4.0	10	5¾	3⅜	2.07

*Hydrogen reservoir connected internally across cathode-heater.
Ambient Temperature Limits −65°C to +125°C ambient, 400°C envelope maximum.

TRIGGERED SPARK GAPS

These compact spark gaps are designed to replace hydrogen thyratrons in electronic crowbar applications. They have a low trigger energy requirement and a fast follow-through time after application of trigger pulse. Hermetically sealed, they are not affected by atmospheric conditions. Ruggedly built to withstand severe shock, vibration and high temperatures. No filament power required. Complete specifications available on request. Write for Data Sheet #080.

CERAMIC-METAL MODEL GP-12
Voltage holdoff — 25kv.
Peak current — in excess of 10,000 amperes
Trigger voltage — 7 kv. min.
Electrode to electrode cut-off voltage — 6 kv. min.
Delay time — 0.5 microseconds.
Size: 3½" dia. x 2½". Wt. .73 lb.

GLASS-METAL MODEL GP-11
Voltage holdoff — 3.5 kv.
Peak current — in excess of 1100 amperes.
Trigger voltage — 7.5 kv. min.
Electrode to electrode cut-off voltage — 1.8 kv. min.
Delay time — 0.35 microseconds.
Size: 0.6" dia. x 0.55". Wt. .016 lb.

EDGERTON, GERMESHAUSEN & GRIER, INC

174 BROOKLINE AVENUE, BOSTON 15, MASSACHUSETTS • TEL. COPLEY 7-9700 • CABLE: EGGINC, BOSTON; TWX: BS 109
WESTERN OPERATIONS: P.O. Box 1912, Las Vegas, Nev. — Santa Barbara Airport, P.O. Box 98, Goleta, Calif.

PRODUCTS — milli-mike® Oscilloscopes • Hydrogen Thyratrons • Hydrogen Diodes • Triggered Spark Gaps • Xenon Flash Tubes • Laser Stimulators • Dosimete Flash Machines & Circuits • Oceanographic Equipment • Transformers • CAPABILITIES — Project Management • Systems Engineering • Research & Developme

EG & G TECHNICAL REPRESENTATIVES — NEW ENGLAND, BOSTON, MASS. — 160 Brookline Ave., COpley 7-9700 **J. D. Ryerson Assoc., Inc. — SYRACUSE, N. Y.,** P. O. Box 1400, 111 Kinne Road, GIbson 6-1771 • **G. Curtis Engel & Assoc., Inc. — RIDGEWOOD, N. J.,** 210 Sou Broad Street, GIlbert 4-1400; **PHILADELPHIA, Pa.,** WAlnut 2-3270 • **S. S. Lee Assoc., Inc. — ORLANDO, Fla.,** P. O. Box 7896, CHerry 1-4445; **WINSTON-SALEN N. C.,** P. O. Box 906, STate 8-0431; **HUNTSVILLE, Ala.,** Utilities Bldg., Room 300, JEfferson 6-0631; **WHEATON, Md.,** 2521 Ennalls Avenue, LOckwood 5-3066; **TOWSON, Md** 21 Pennsylvania Ave., VAlley 3-3434 • **Dayton Assoc. — DAYTON, O.,** Talbot Tower — Suite 1318, BAldwin 3-9621; **CLEVELAND, O.,** 8211 Avery Road, JAckson 6-399 **CINCINNATI, O.,** 4924 Zula Avenue, BAckburn 1-2349; **SOUTHGATE, Mich.,** 15332 Kennebec, AVenue 5-3125 • **Midwest Electronic Sales — CHICAGO, Ill.,** 380 West North Ave., CApitol 7-3222 • **Engineering Production Assoc. — ST. PAUL, Minn.,** 1821 University Avenue — Rm. 182, MIdway 6-3443 • **Gene French Co. — ALBUQUERQUE, N.M.,** 7900 Zuni Road, S.E., AMherst 8-2478; **SALT LAKE CITY, Utah,** 138 South Second East, EMpire 4-3057; **DENVER, Col.,** 1480 Hoyt, MAin 3-145 **Kinrick Co. — ST. LOUIS, Mo.,** 222 Olympia Drive, JAckson 1-4877, MAin 1-1421 • **Stanley Enterprises — SEATTLE, Wash.,** 127 River Street, PArkway 3-3320 • **Mitche Speairs Co. — FORT WORTH, Tex.,** 4944 James Avenue, WAlnut 3-4657 • **J. T. Hill Co. — SAN GABRIEL, Calif.,** 420 South Pine Street, ATlantic 7-9633, CUmberlan 3-6555; **SAN CARLOS, Calif.,** 1682 Laurel Street, LYtell 3-7693; **SAN DIEGO, Calif.** • 1864 Bacon Street, ACademy 3-7138.

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BRAND-REX REXOLITE 1422®
Microwave Dielectric Gives You New Design Flexibility!

You Can Machine It! Mill, drill, tap, grind, form, or turn it . . . Rexolite machines smoothly, evenly, with precision! It's ideal for hundreds of different applications because you can design it into just about any mechanical shape. Rexolite is available in sheets or rods.

Radiate It! The tensile, impact and especially dielectric properties of Rexolite are not affected by radiation . . . and this is important, because ionizing radiation is becoming a common environmental hazard for the electronic equipment you design.

Load It! Under a range of loads from 10 psi to 2000 psi at temperatures from 20°C to 200°C, Rexolite 1422 will not exhibit permanent plastic flow.

And, Have Dielectric Stability, Too! An ultra-high frequency insulation material, Rexolite 1422 has a wide range of electrical advantages . . . low dielectric constant, low dissipation factor, and high dielectric strength over a wide frequency range! **To Give New Line To Your Design — Send For These Free Bulletins!**

BRAND
REX

DIVISION OF American ENKA Corporation
Dept. R, 37 Sudbury Road, Concord, Massachusetts
TELEPHONE: EMERSON 9-9630

Vinyl, Teflon, Polyethylene, Nylon Wire and Cables, Electrical Tubing and Sleeving — UHF Cast Plastics.

Gentlemen: Please send the bulletins on Rexolite 1422 that I have checked below:

Name .... Title ....

Company ....

Street ....

City .... Zone .... State ....

..............Machining Rexolite ....Rexolite Deformation Under Load

..............Rexolite Radiation Report ....Rexolite Dielectric Properties

Rexolite 1422 is another member of the growing Rexolite family of dielectrics.

"See us at the Wescon Show . . . Booth 4604"
Circle Reader Service Card 11

14' TO 32'

PARABOLIC REFLECTORS AND ACCESSORIES

Taco parabolic antennas are engineered and built to the highest standards of performance, dependability and versatility. The basic Taco design permits easy transportation, and fast, accurate assembly at installation site. Tolerances are closely held for maximum efficiency. A wide choice of mounts permit tower, ground, remote control, or other mounting installations. Feeds available are dipoles, horns, dual-polarized horns, or special designs to meet customer specifications.

WRITE FOR COMPLETE TECHNICAL SPECIFICATIONS AND PERFORMANCE INFORMATION...Catalog No. 500

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Ruggedized yagis CAT. NO. 600

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CAT. NO. 500 Large parabolics from 14' to 32'.

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Write for Catalog . . . Defense & Industrial Div.

TACO

TECHNICAL APPLIANCE CORPORATION, SHERBURNE, NEW YORK
Area Code 607 • Telephone OR 4-2211

Industry News

(Continued from page 14)

microwave tube, vacuum tube and industrial systems divisions. Previously he wa military relations manager for Texa Instruments, Inc.

Trantham is a member of the Institut of Radio Engineers, American Manag ment Association, Electronic Industrie Association, American Society of Minin Engineers, and is national treasurer of th Armed Forces Communications and Electronics Association.

—mwj—

PAGE DESIGNS MOBILE TROPOSCATTER SYSTEM

Page Communications Engineers, Inc Washington, D.C., a Northrop Corporation subsidiary, has designed and i providing a completely mobile tropospheric-scatter communications system fo the U. S. Air Force.

Designated the AN/MRC-85, each dua 10-kw, all-environment, vanized, trop station comprises two 4-wheel trailers with a 28-foot paraboloidal antenna mounted on each, and three 2-whee semitrailer equipment vans. The stations for USAF use overseas, are being assembled by Adler Electronics and ITE Circuit Breaker Company under subcontrac from Page.

Two of the semitrailer vans house an transport dual 10-kw transmitters an associated equipment, parametric amplifiers, quadruple-diversity receivers, exciters, performance test equipment, voic and telegraph multiplex, signaling equipment, wire distribution frame, storage area, maintenance facility, transmittin and receiving filters with associate waveguide, and heating and air-conditioning units.

—mwj—

DUNBAR WILL MANAGE SPACE FLIGHT ACTIVITIES

Allen S. Dunbar has been named manager of space flight activities at the Maryland Division of Litton Systems, Inc., i has been announced by Russell McFall vice president and general manager.

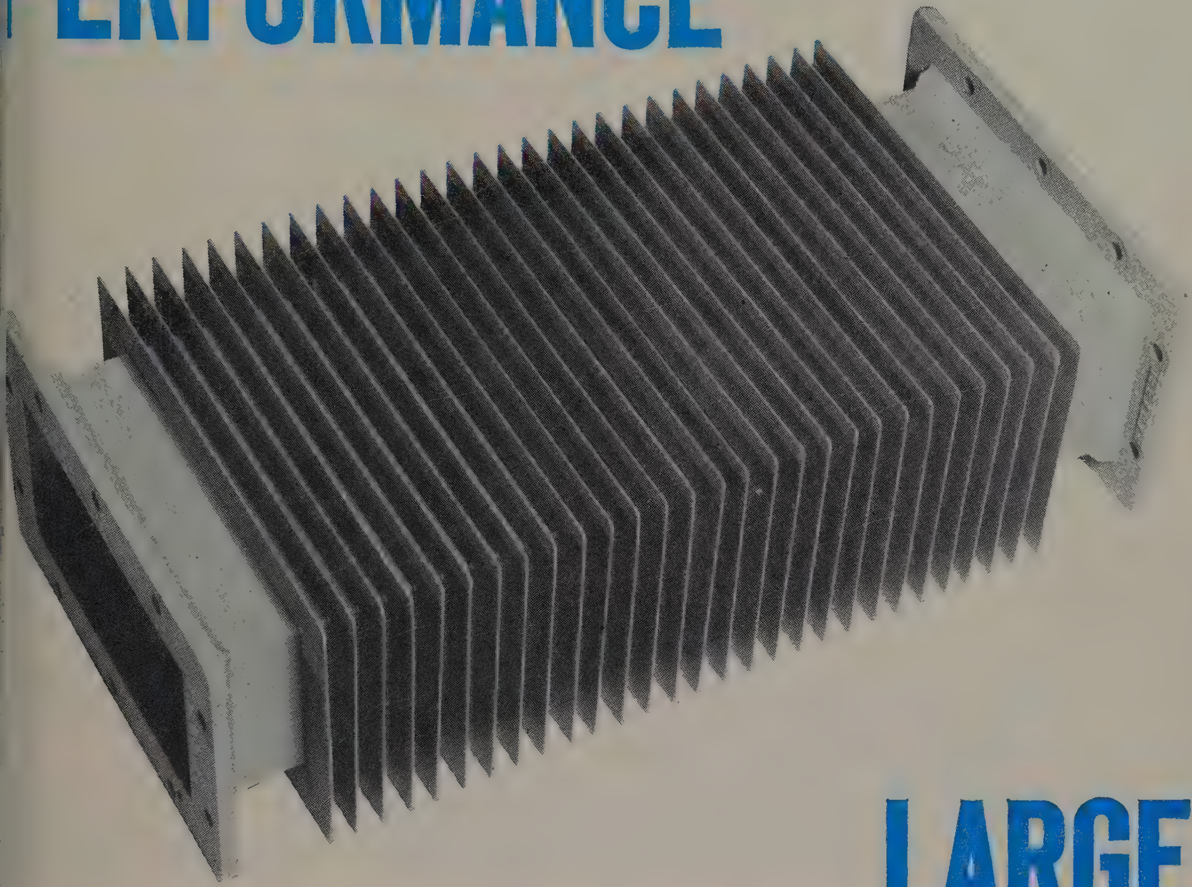
The division has equipped a 14,000 square-foot building near its College Park, Md., headquarters to fulfill a contract with the National Aeronautics and Space Administration for data reduction and component development.

Dunbar will direct scientists and technicians who are engaged in reducing data obtained from satellite and space probe programs. Others will be engaged in model fabrication and testing of advanced satellite and space probe components.

—mwj—

(Continued on page 22)

HIGH
PERFORMANCE



LARGE
WAVE GUIDE

NOW, the advanced design techniques of Applied Microwave Electronics and the engineering competence and manufacturing know-how of Washington Aluminum Company are combined to provide industry with he most comprehensive line of large waveguide components. This successful combinaion of creative capability and custom craftsmanship means high quality, yet economical, production of: Straight Sections (VSWR 1.02), Bends (VSWR 1.03), Coax o Waveguide Transitions, Directional Couplers, Fixed Terminations, Sliding Terminaions, Sliding Short Circuits, Taper Secions, Slotted Lines and Finned Waveguide.

This added to our present proven antenna capabilities assures that we can accept systems responsibility for integration of all passive microwave equipment.

DIRECT INQUIRIES TO:
APPLIED MICROWAVE ELECTRONICS, INC.
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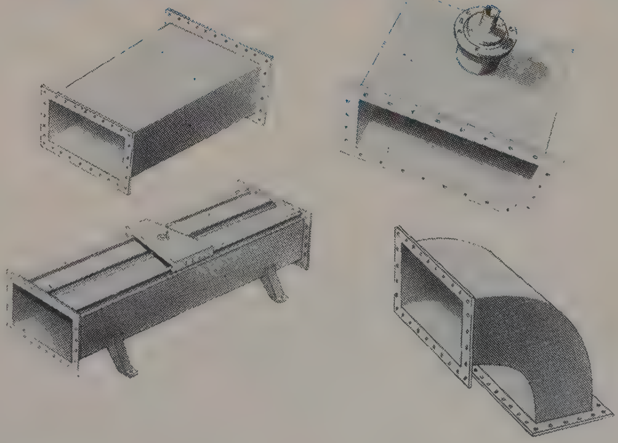

APPLIED MICROWAVE ELECTRONICS WASHINGTON ALUMINUM CO., INC.

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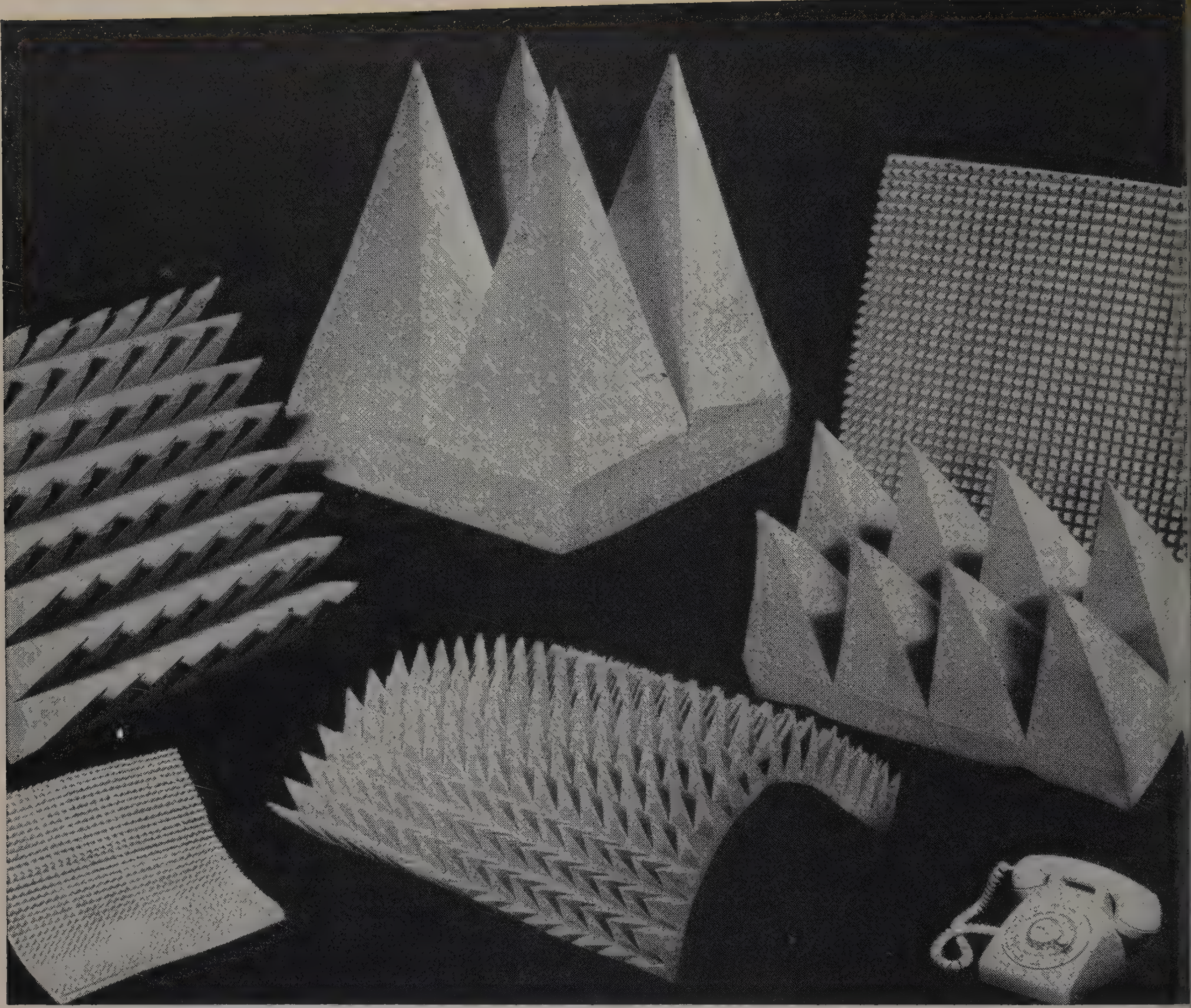

Absorbers take new shape to provide very high performanc

B.F.Goodrich "sharp-point" design improves testing reliability in anechoic chambers

These newly-developed VHP (very high performance) broadband microwave absorbers can substantially improve the performance of anechoic chambers.

They can eliminate baffles yet provide chambers with lower reflection levels than previously existed. They can improve the performance of existing chambers by application to rear wall and/or center region. Their inherent high attenuations eliminate the need of additional metal shielding where moderate isolation is required. And because of Type VHP's excellent wide-angle absorption, chambers with reduced cross-section area can be used.

To take a specific example, Type VHP-18 at X band offers these outstanding electrical features.

- Reflection down by approximately 60 db for angle near normal incidence.
- Reflection down 40 to 50 db for both polarizatio at angles of 60° to 65° from normal incidenc (angles most often encountered in anechoic chambe sidewalls).
- Attenuation through the material in excess of 50 d

B.F.Goodrich VHP absorbers are light, semi-flexibl easy to install. A variety of thicknesses, as shown i picture, enables the engineer to choose the desire absorption level and frequency range. If you would lik more information on VHP absorbers, or want to kno more about an entire line, just write *B.F.Goodrich Spong Products, 130 Derby Place, Shelton, Conn.*

MICROWAVE ABSORBERS BY B.F.Goodrich

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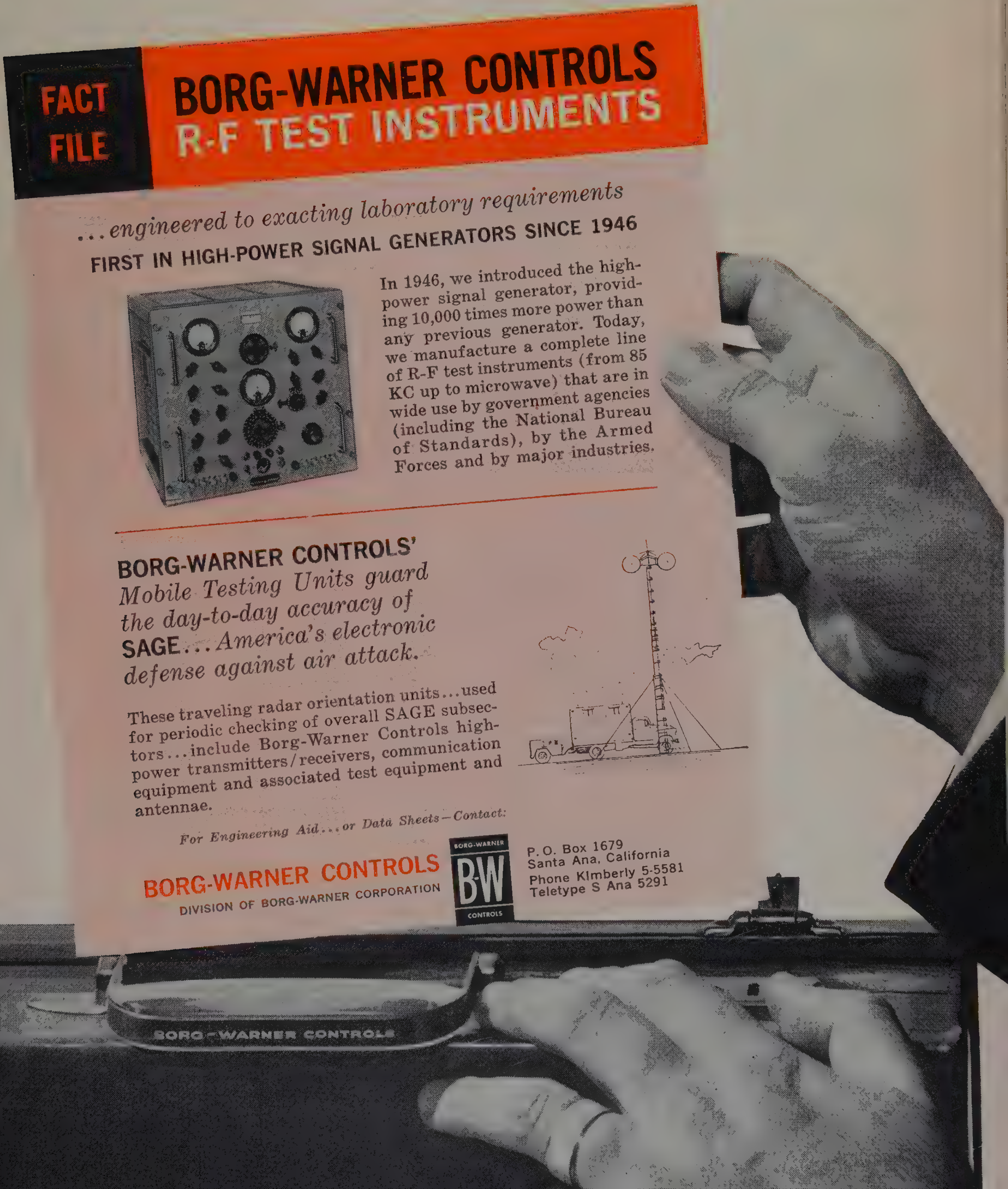
Circle Reader Service Card 15

"Frankly, we've been first in High-Power Signal Generators but last in advertising"



FACT FILE

BORG-WARNER CONTROLS R-F TEST INSTRUMENTS

...engineered to exacting laboratory requirements

FIRST IN HIGH-POWER SIGNAL GENERATORS SINCE 1946

In 1946, we introduced the high-power signal generator, providing 10,000 times more power than any previous generator. Today, we manufacture a complete line of R-F test instruments (from 85 KC up to microwave) that are in wide use by government agencies (including the National Bureau of Standards), by the Armed Forces and by major industries.

BORG-WARNER CONTROLS' *Mobile Testing Units guard the day-to-day accuracy of* **SAGE**...*America's electronic defense against air attack.*

These traveling radar orientation units...used for periodic checking of overall SAGE subsectors...include Borg-Warner Controls high-power transmitters/receivers, communication equipment and associated test equipment and antennae.

For Engineering Aid...or Data Sheets—Contact:

BORG-WARNER CONTROLS
DIVISION OF BORG-WARNER CORPORATION

P. O. Box 1679
Santa Ana, California
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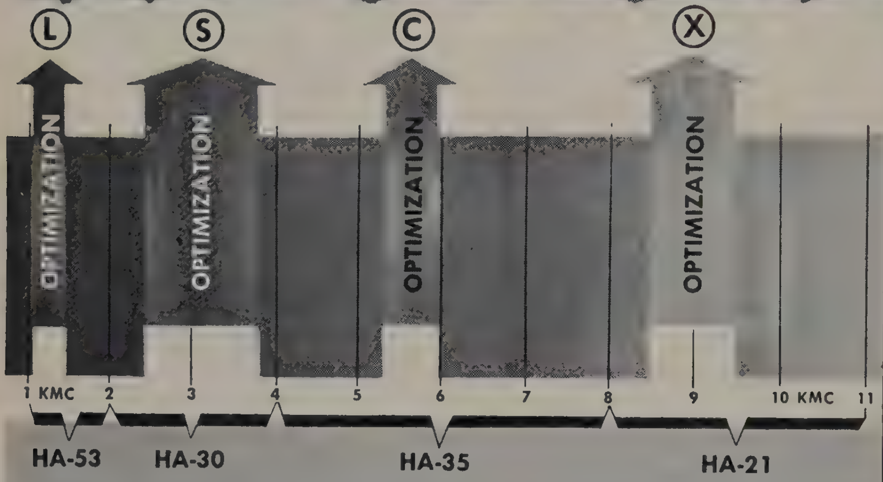
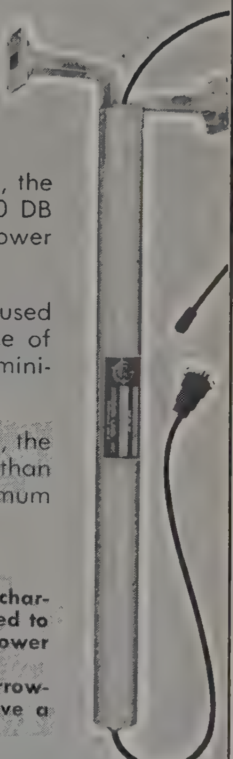
TWT's OPTIMIZED for NARROW BAND USE

GREATER POWER OUTPUT

INCREASED SMALL SIGNAL GAIN





Ⓛ **1.1 - 1.4 kmc** The PPM focused type HA-53, normally operated from 1 - 2 kmc, when optimized is capable of greater than 35 DBM power output and 40 DB small-signal gain.

Ⓢ **2.4 - 3.8 kmc** Cataloged as a 2 - 4 kmc amplifier, the PPM focused HA-30 exhibits greater than 40 DB small-signal gain, with 33 DBM minimum power output over the narrow band.

Ⓒ **5.3 - 6.0 kmc** The HA-35, a 4 - 8 kmc solenoid focused amplifier, displays narrow-band performance of 32 DBM minimum power output, and 45 DB minimum small-signal gain.

Ⓧ **8.5 - 9.5 kmc** Normally operated from 8 - 11 kmc, the PPM focused type HA-21 is capable of more than 45 DB small-signal gain, and 31 DBM minimum power output when optimized.

Although the traveling wave tube is best known for its characteristics over a broad frequency range, it may be optimized to operate over a narrow band with outstanding results. Power output and small-signal gain are significantly increased.

If your system application requires a high-performance, narrow-band amplifier, contact Huggins Laboratories. We may have a TWT with the exact characteristics for your system.

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Circle Reader Service Card 16

Industry News

(Continued from page 18)

RIZZI HEADS NEW MICROWAVE FIRM

Microwave Technology, Inc., a ne microwave company, was recently form at Waltham, Ma achusetts. The fi is headed by D Peter A. Rizzi, fo merly of the Ewe Knight Corp. whe he was director the Microwave D vices Group.

Microwave Tec nology Inc., w specialize in pa metric am plifie masers, linear and non-linear ferrite d vices, semiconductor switches, frequen multipliers and millimeter componen Present plans also call for the develo ment of a product line as well as hea participation in research and developme programs for both industry and the go ernment.

In addition to an experimental mod shop, the company has available su stantial manufacturing facilities and c supply both pilot production and full pr duction quantities of microwave device

The engineering staff headed by D Rizzi has extensive experience in the m crowave field. Dr. Rizzi has recently be concerned with low noise microwave a plifiers, semiconductor switches and f rite devices.

— mwj —

WALDMAN JOINS MELABS

Marvin D. Waldman has joined Mela Palo Alto, Cal. electronics firm, as m ager of the anten systems and co ponents branch.

He will be sponsible for search and devel ment of anten systems and co ponents, and m netic and mic wave devices.

During the p 10 years Waldm has been with Sylvania, most recently manager of the microwave and anten section of the Reconnaissance Syste Laboratory in Mountain View, Cal.

He received his BSEE degree from University of Massachusetts in 1950, a his MSEE degree from the University Michigan in 1951. He is a member of IRE, RESA, Tau Beta Pi, and the revi board of *the microwave journal.*

— mwj —

(Continued on page 25)

SPERRY *Microline*®

31A1
AVERAGE POWER METER

AVERAGE POWER METER MODEL 31A1
SPERRY MICROWAVE ELECTRONICS COMPANY
SPERRY Microline

NOW!

MEASURE POWER TO 3%

MOST ACCURATE instrument of its kind on the market. Has unmatched stability. Sperry Microline 31A1 can be used to measure pulsed or C-W power of radar, radio, television, microwave and microwave relay equipment and components. Priced competitively low.

EASY TO BALANCE. In addition, two scales (0-10 db and 5-15 db) permit its use for direct attenuation measurements. Its frequency coverage is limited only by the range of the bolometer and mount used. D-C bias adjustment is set by a 12-position switch.

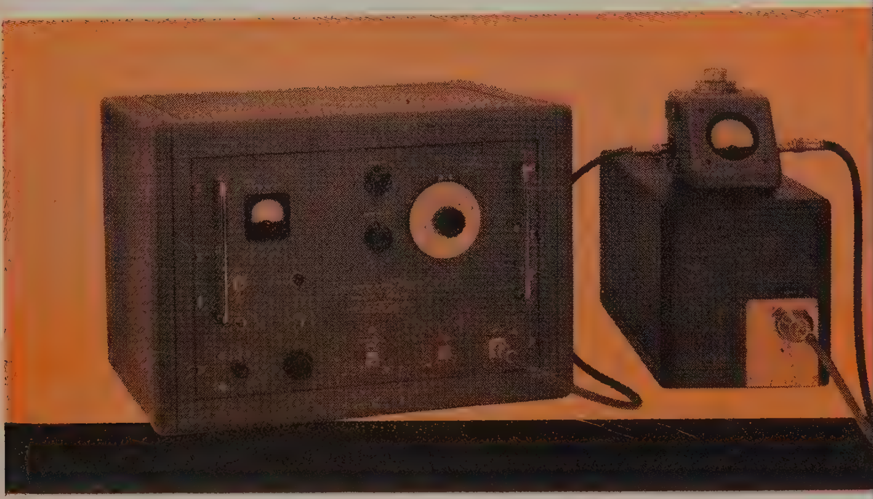
SPERRY

Scales:	Five ranges, front panel selection: 0-.1, 0-.3, 0-1.0, 0-3.0, 0-10 milliwatts full scale. Two ranges 0-10, 5-15 db full scale. Higher power levels by using directional couplers and/or calibrated attenuators.
Accuracy:	3% of full scale reading.
Power:	105-125 volts, 210-230 volts, 50-60 cps.
Bolometer:	Temperature coefficient: positive or negative, front panel selected. Resistance: 100 or 200 ohms, front panel selected.
Bias Current:	0-16 ma d-c
Recorder Output:	0-1 ma, 1500 ohms, one side ground
Oscillator Frequency:	10.7 kc.
Weight:	Approximately 13 lbs.
Price:	$240.

PERRY MICROWAVE ELECTRONICS COMPANY, *CLEARWATER, FLORIDA · DIVISION OF SPERRY RAND CORPORATION*

Ready for you now!

Primary standard accuracy for power measurements to 1,000 watts!



Sierra 290B Test Set

Frequency coverage dc through 12.4 KMC.

Precise ac wattmeter, calorimeter and heat exchanger in one neat, rack unit. Separate dual loads for dc to 4 KMC, also C, XB, X bands. Direct reading linear scale.

Above are highlights of the new Sierra 290B Calorimetric Wattmeter Test Set—the industry's closest approach to absolute power measurements in this range.

Model 290B measures power in three distinct modes.

1. For power levels 30 to 1,000 watts, a null-balance mode provides measurement accuracies of 1% or better, with probable error as low as 0.5%.

2. For wider range power levels from 10 to 1,500 watts, a direct-reading mode provides excellent linearity in thermal readout and 2% to 3% accuracy. Readout is fast—60 seconds or less.

3. For expanded scale readings of highest resolution, the above two modes may be combined in a third mode to obtain the order of accuracy of the null-balance mode, together with the time-saving convenience of the direct readout mode.

Model 290B, $4,500.00. (Water loads, extra.)

Data and prices subject to change without notice. Prices f.o.b. factory.

Laboratory setup above shows Sierra Model 21 Power Source being used in conjunction wit Model 290B Calorimeter to calibrate Sierra Bi Directional Power Monitor. Designed specifically for calibration purposes, 215 series Source include four 50 watt models covering, collectively, 25 to 1,000 MC. Model 215A, 25 to 50 MC; Model 215B, 50 to 150 MC; Model 215C 150 to 470 MC; Model 215D, 470 to 1,000 MC Price (any model) $3,300.00.

For complete details, see your Sierra representative or write direct

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6560

sierra

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(Continued from page 22)

HILCO OPENS NEW FACILITIES

Philco Corp. formally opened a new ,000 square foot building in the Fort ashington Industrial Park, Fort Washgton, Pa., to house its expanding Comunications Systems Division.

The $1,000,000 building provides facilies for the development of large and mplex communications for government d industry.

The division's general manager, Maj. en. E. B. Garland, USAF Ret., told me 400 employees and visitors attendg the dedication that the facility and s work "underline the burgeoning imrtance of improved communications pabilities."

The newest member of Philco's Govrnment and Industrial Group, Comunications Systems Division has grown uring the past two years from a staff of alf a dozen employees to its present 50. Since it was organized the division as completed communications assignents for the armed forces and industry, anging from the installation of small icrowave radio links to an overall modrnization of the Air Force's worldwide mmunications network.

—*mwj*—

MICROSONICS MERGES WITH SANGAMO

Controlling stock interest of Microonics, Inc., Hingham, Mass., manufacrers of delay lines, has been purchased y Sangamo Electric Co. Microsonics will ontinue to operate in their present facilies.

Plans call for an immediate and rapid xpansion of the research and developent facilities of Microsonics aimed at ore esoteric types of solid delay lines, nd other new product developments.

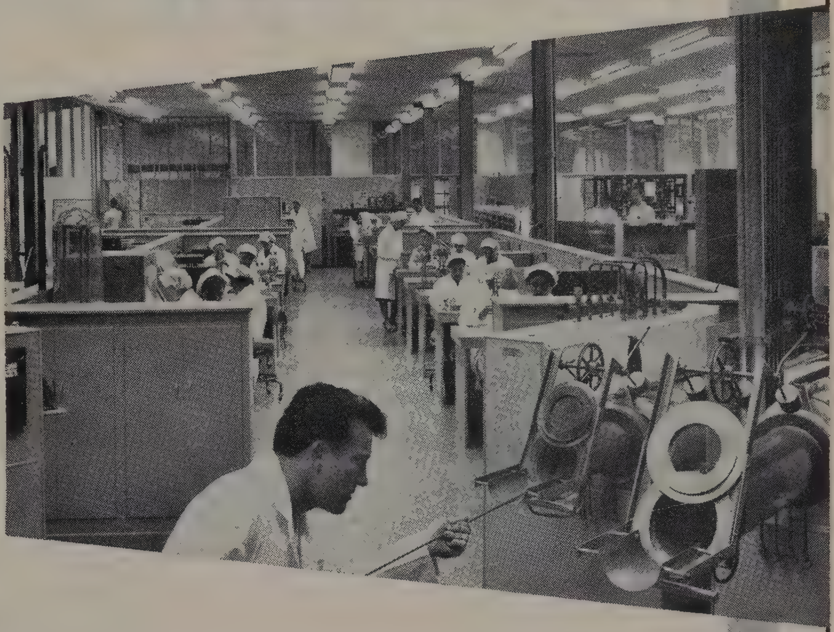
Many of the products and developents at Microsonics will find important ses in systems now being produced by angamo for Government agencies and or manufacturers of computers and data athering equipment. Sangamo engineers re studying the possible application of ome of the Microsonics products to agnetic tape transports.

T. J. Geoghegan remains as President, Chief Executive Officer, and member of he Board of Microsonics. The Board of Directors has been reconstituted to inlude as Chairman, C. H. Lanphier, President of Sangamo Electric Company, nd as members, C. L. Clark, Vice President and Treasurer, E. A. Leach, Vice President and Manager of the Custom Products Division, and Howard E. Rhodes, Assistant to the President, Sangamo Electric Co.

—*mwj*—

(Continued on page 28)

RESEARCH
DEVELOPMENT
PRODUCTION



Watkins-Johnson Company is making traveling-wave tubes at the lowest noise figures in the industry. The WJ-211 and WJ-212, produced in super-clean, air-conditioned tube facilities, are now being manufactured in quantity and are offered at guaranteed noise figures below 4 db in S-band and L-band.

Information in more detail available from representatives in your area, or from

APPLICATIONS ENGINEERING
WATKINS-JOHNSON COMPANY
3333 HILLVIEW AVENUE
STANFORD INDUSTRIAL PARK
PALO ALTO, CALIFORNIA

Circle Reader Service Card 19

" THE DEVELOPMENT OF THE MICROWAVE FIELD HAS BEEN FULLY AS SPECTACULAR AS WE EVER PRESUMED . . . "

microwave horizons --three years later

SEYMOUR B. COHN, ASSOCIATE EDITOR, *the microwave journal*

Three years have gone by since the first issue of the Microwave Journal was published. That issue contained my editorial "Microwave Horizons" — a highly optimistic statement reflecting our personal confidence in microwaves as a field of professional endeavor as well as a field in need of a new-born publication.

Now, three years later, the hopeful projections of my first editorial can be viewed more objectively and compared to the test of time. The development of the microwave field has been fully as spectacular as we ever presumed and is yet on the steep slope of growth. The field still has potential and challenge, and should continue to retain these qualities.

It is interesting to re-read my first editorial, and to compare the predictions with the technical advance of the past three years. Looking back, "We are still in a six-year-old major surge of advance on ferrite applications . . ." Today the main surge of technical advance in ferrite devices appears to be over. Excellent performance has been achieved in waveguide and coaxial line. In most respects the problems now are those of production methods and competition . . . how to turn out quantities of isolators, circulators, etc., at the lowest possible prices.

Many problems still remain, however, that could be important for the future. Some of these are improvement of isolator and circulator designs at both edges of the microwave frequency range, and nanosecond switching techniques.

Another statement was "We are in the initial phase of what will doubtless prove to be a major forward surge on solid-state masers and parametric amplifiers." This has proved true. Masers and parametric amplifiers have lived fully up to expectations, and are already in practical use.

Research and development activity on these devices is still intense and further important advances can be expected.

The first editorial predicted areas in which major advances might occur, and some have already been realized. The other advances hopefully anticipated may still be achieved in the future.

One statement has proved significantly correct. "Because of the great rate of improvement in the understanding of the solid state and the synthesis of new unusual materials, it is reasonable to expect other important contributions to microwaves from that field. Not only has this proved true in the past three years but we may confidently expect research on the soli state to produce numerous new breakthroughs for m crowaves over the next decade.

Important advances in varactors, single crystal garnets, maser crystals, and switching diodes have bee made. Probably the outstanding completely new solid state device having microwave significance since the first editorial is the tunnel diode. Successful applications to oscillators, harmonic generators, and amplifiers have already been made at the lower microwave frequencies. Improved tunnel diodes for use at higher frequencies seem imminent.

The advance expected in electronically tunable filter has been made with the practical development of circuits using narrow-line-width single-crystal yttrium-iron garnet spheres. An allied advance, although not predicted in the editorial, has been power limiters utilizing narrow-line-width ferromagnetic elements. There appears to be considerable potential in these applications, although important problems remain.

A reliable, low-loss ferroelectric material is desired that "would make possible many applications to the voltage control of microwave components and circuits. Unfortunately, three years of research in several laboratories have not yielded the hoped-for breakthrough. The best ferroelectric materials still are highly temperature sensitive, and have Q's only in about the 5 to 20 range Apparently, no practical microwave application of electronically controlled ferroelectric elements has yet occurred, and none appear likely unless a material is developed that offers a wide variation in dielectric constant with a Q on the order of 100.

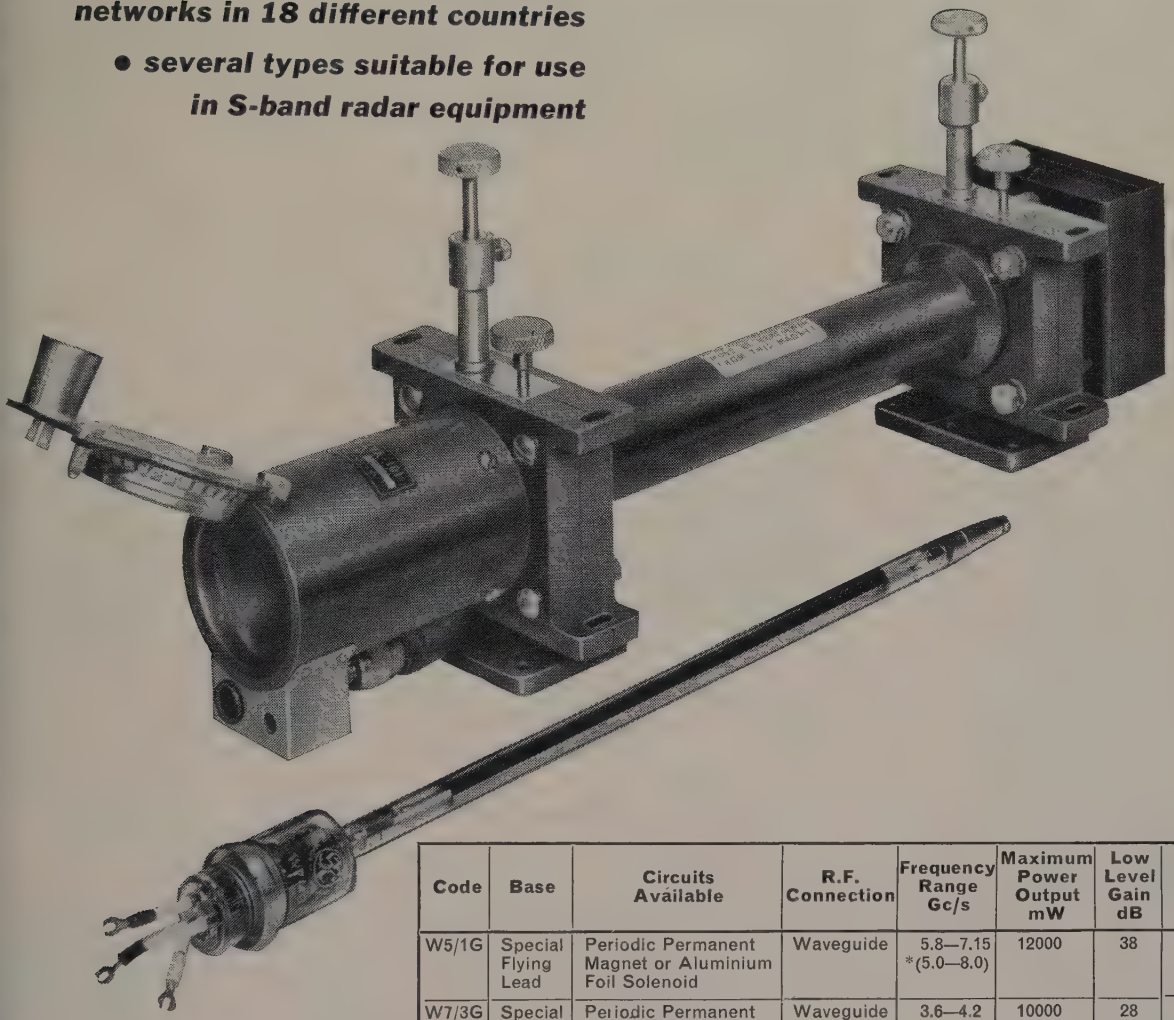
Another microwave medium that has not yet lived up to expectations is the gas-discharge plasma, which

(Continued on page 28)

STC

TRAVELLING WAVE TUBES

- ***used in communication networks in 18 different countries***
- ***several types suitable for use in S-band radar equipment***



Code	Base	Circuits Available	R.F. Connection	Frequency Range Gc/s	Maximum Power Output mW	Low Level Gain dB	Noise Factor dB
W5/1G	Special Flying Lead	Periodic Permanent Magnet or Aluminium Foil Solenoid	Waveguide	5.8—7.15 *(5.0—8.0)	12000	38	—
W7/3G	Special Flying Lead	Periodic Permanent Magnet or Aluminium Foil Solenoid	Waveguide	3.6—4.2	10000	28	25
W7/4G	Special Flying Lead	Periodic Permanent Magnet	Waveguide	3.6—4.2 *(3.6—5.0)	10000	42	25
			Coaxial	2.6—3.7	8000	36	25
W9/1E	Special B9A	Aluminium Foil Solenoid or Permanent Magnet	Coaxial	2.5—4.1	120	36	18
W9/2E	Special B9A	Aluminium Foil Solenoid	Coaxial	2.5—4.1	10	40	8.5
W9/3E	Special B9A	Aluminium Foil Solenoid	Coaxial	2.5—4.1	0.3	15	16
W10/3E	Special B9A	Copper or Aluminium Foil Solenoid	Waveguide	2.7—3.3	3	23	6.5
			Coaxial	2.8—3.7			

* Bracketed frequency limits indicate extension or range for reduced performance.

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COHN

(Continued from page 26)

is still used principally in T-R tubes and noise sources. The applications to oscillators, amplifiers, phase shifters, nonreciprocal devices, and switches have not developed.

There are several reasons for this situation, such as practical difficulties in avoiding contamination of the gas, short tube life, and noisy output. The most important deterrent to gas discharge devices has been the more successful development of competing solid-state devices, which in general are more compact, more reliable, less power consuming, and better performing. In the case of gas-discharge plasmas, as with ferroelectrics, this pessimistic picture could change abruptly if a substantial improvement could be made in this medium, or if a new application is conceived.

"New applications for microwaves will greatly e pand our field." Some of the predicted applicatio were millimeter-wave transmission in circular wa guides, space communications, control of industrial pr cesses by microwave spectroscopy, and thermonucle power generation. To these might be added glob communication with the aid of satellites and high-spe computers utilizing microwave circuitry and techniqu

Thus, three years later the microwave field is still exciting, challenging and changing frontier. Anoth three years will doubtless see further technical advan and growth. Some advances will be ones predic here, but others will be completely new and surprisi

It is as true today as it was three years ago that " cannot see past the horizon, but we know that the mirable inventive genius of man will never be satisf and that there will be new vistas to explore that cannot predict or imagine now."

Industry News

(Continued from page 25)

POLARAD ACQUIRES FEDERAL SCIENTIFIC

Negotiations have been successfully concluded for the acquisition of Federal Scientific Corporation of New York by Polarad Electronics Corp., Long Island, N. Y., Dr. D. Lawrence Jaffe, president of Polarad, announced. Federal Scientific Corporation is presently privately owned and will continue to be operated autonomously by its present management.

Polarad's industrial products marketing organization will distribute Federal Scientific's proprietary instrument line. Federal Scientific Corp.'s scientific talents will assist Polarad's defense products division in further increasing its participation in advanced space technology.

—mwj—

SINCLAIR BECOMES SENIOR ENGINEER AT QUANTATRON

John G. Sinclair, Jr., has joined the Microwave Laboratories of Quantatron, Inc., Santa Monica, Cal., as senior engineer, according to Leonard Pincus, vice president of Quantatron and director of the Microwave Laboratories.

Prior to joining Quantatron, Sinclair served for over 11 years as a member of the technical staff, Hughes Aircraft Co. Most recently, he was at Hughes Nuclear Electronics Laboratory, where he designed high-power pulse modulators and associated rf equipment.

Sinclair is a senior member of IRE and president of the Science Center, a modern science museum for Southern California.

—mwj—

BEGOVICH APPOINTED HUGHES VICE PRESIDENT

Dr. Nicholas A. Begovich, the scientist responsible for the development of three-dimensional radar at Hughes Aircraft Co., Culver City, Cal., has been appointed a vice president, according to Lawrence A. Hyland, vice president and general manager.

Dr. Begovich, who is assistant manager of the company's ground systems group in Fullerton, Cal., and director of product line operations there, conceived the idea of radar scanning by electronic means rather than mechanical. He later invented a family of 3-D radars manufactured by Hughes and now used in the armed forces.

Dr. Begovich joined Hughes as a research physicist in 1948 after receiving bachelors, masters and doctors degrees from the California Institute of Technology. He was an instructor in electrical engineering at Caltech from September, 1947 to June, 1951.

—mwj—

MICROPHASE MOVES FACILITIES

Microphase Corp., Greenwich, Conn., manufacturers of RF filters and microwave components, announces the moving of its engineering offices and its research and prototype facilities into a new 8500-square-foot plant on River Road, in Cos Cob, Conn. This building will be utilized primarily for advanced development work in microwave components, filters and solid-state devices.

The 12,000-square-foot Greenwich plant, at 1 Seneca Place, will continue to serve as the company's manufacturing facility and will partially be used to conduct environmental tests on the Microphase products.

—mwj—

MELABS APPOINTS TWO SECTIC HEADS

Theodore D. Geiszler and Franklin Coale have recently been appointed Se tion Heads of newly organized groups Melabs, electronics firm in Stanford dustrial Park, Cal.

Geiszler has been appointed Secti Head of the new Magnetic Devices gro of the Components and Antenna Syste Branch. He previously was a project e gineer in the Components Branch.

Mr. Geiszler joined Melabs in 19 after receiving his BS degree in electri engineering from San Jose State Colle

Coale was named Section Head of t new Waveguide Devices Section of t Components and Antenna Systems Branc He previously was an engineering spe ialist in the Components Branch.

—mwj—

FXR ELECTS EBERT BOARD MEMBER

John E. Ebert, vice president, microwa division, of FXR, Inc., Woodside, N. has been elected to the company's board of directors, Henry Feldmann, chairman and president, announced.

Mr. Ebert has been engaged in the engineering and management phases of the microwave and electronics industry for the past 19 years. He joined FXR in 1953, an is in charge of the engineering aspec of FXR's proprietary line of microwa test equipment as well as custom micr wave and electronic components.

Before coming to FXR, he was asso ated with the Microwave Research Inst tute of the Polytechnic Institute of Broo lyn, and with PRD, Inc. He also taug electrical engineering at Polytechnic.

—mwj—

FREQUENCY MULTIPLIER SUBASSEMBLY DEVELOPED

mprovement in the precision of re- led doppler frequency measurements is orted in the new frequency multiplier assembly which Space Electronics p., Glendale, Cal. is developing under 12,000 contract from NASA's Jet Pro- sion Laboratory of Cal. Institute of hnology, the company has reported.

he frequency multiplier subassembly be capable of operating over a broad d of input frequencies and will be able for use in the Goldstone duplicate dard data handling system, SEC said. ler its contract, the firm will develop, icate, test, and deliver three units.

he phase-locked loop approach will be d for the broadband frequency multi- r because, according to SEC, it pro- es an accurate stable proved design h a minimum of circuitry.

—mwj—

IPINSKI JOINS LENKURT STAFF

ndrew J. Lipinski has joined Lenkurt ctric Co., Inc., San Carlos, Cal., as a Product Planning staff member.

The Polish-born scientist had been with Canadian Westinghouse Co., Ltd., Hamilton, Ontario, Canada, since 1953. His last position there was as manager of General Communications Engineering De- tment.

He earned a diploma from the Imperial llege of Science and Technology, Lon- n, England, and received his bachelor science degree from the City and Guilds llege, one of the three divisions of the perial College. He is an associate mem- of London's Institution of Electrical gineers.

Lipinski has been awarded more than a zen English, Canadian and U. S. patents such inventions as a waveguide at- uator, a special radar system for detec- n of low-flying aircraft, a coaxial iable resistor, and a diode bridge base- nd combiner.

—mwj—

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—mwj—

(Continued on page 40)

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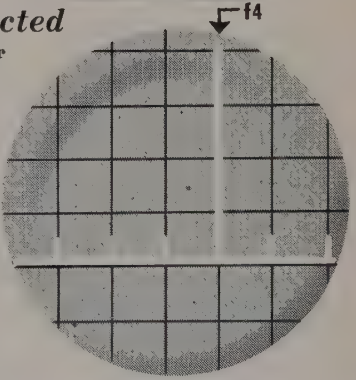

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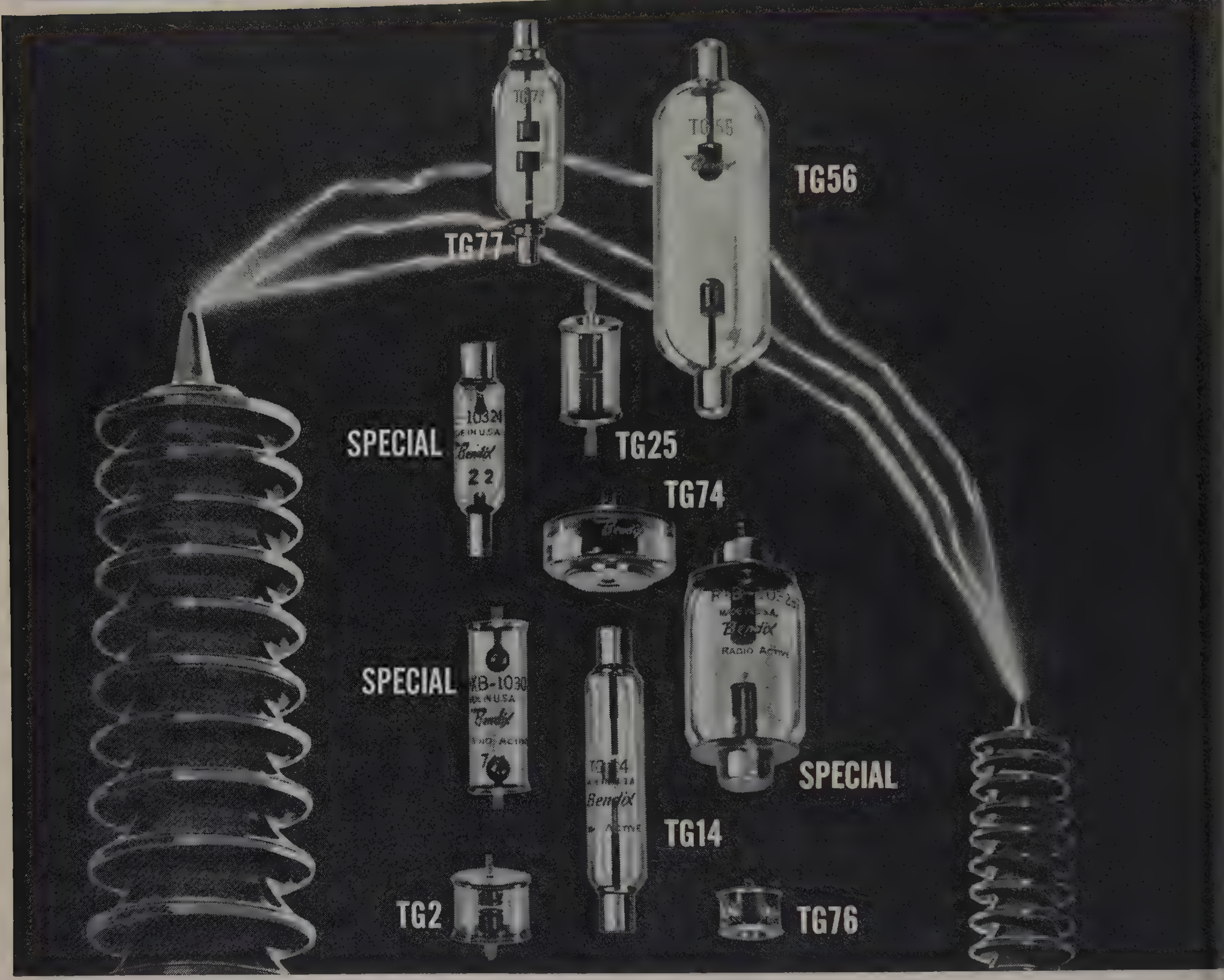

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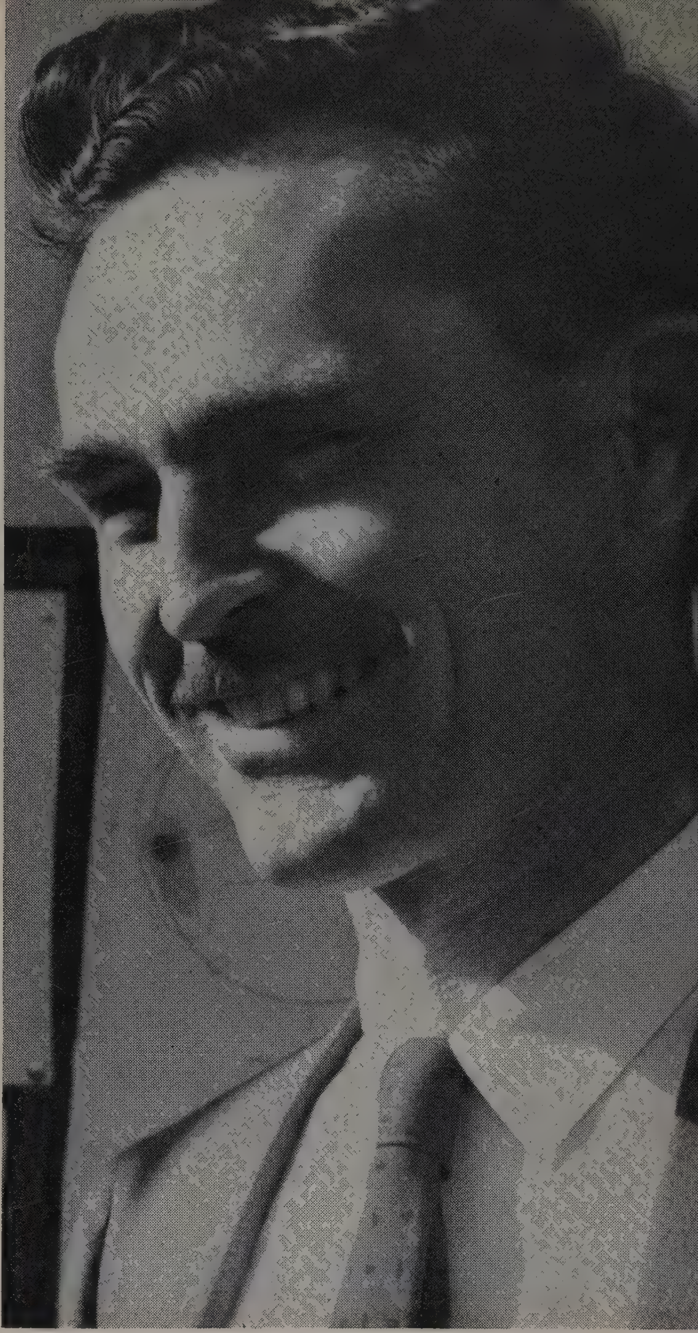
DR. RONALD N. BRACEWELL

Director

STANFORD RADIO ASTRONOMY INSTITUTE

Stanford, California

By ADELAIDE PAINE



Though the Martians and their flying saucers are unlikely to exist in our solar system, Dr. Ronald N. Bracewell, Director of the Stanford Radio Astronomy Institute, does not rule out the presence of stellar-powered probes from superior galactic communities. These could contain durable radio transmitters for the purpose of attracting the attention of technologies such as ours. He made this statement at an alumni meeting of Stanford University in 1960 and later in "Nature" magazine.* He based his remarks on the argument that planets are a common by-product of the formation of stars, and in view of the acceleration with which technology developed, advanced societies could be incredibly more advanced.

"It caused quite a stir," Dr. Bracewell commented. "Even made the front page of the New York Times at one point."

Though the nearest intelligent life may be 100 light years away, he says, "The important thing for us is to be alert to the possible interstellar origin of unexpected signals. We must avoid relegating them, if they are there, to the fate of the strong emissions from Jupiter which were heard and ignored for years."

It would appear at first glance that Dr. Bracewell, a medium-sized man, might well be weighted down by scientific degrees, fellowships, and memberships which he is party to. He is not only a Fellow of the Institute of Radio Engineers and Fellow of the Royal Astronomical Society, but IAU Member of the Inter-Union Committee on the Ionosphere and Exosphere as well as Member of the Committee on Cosmic and Terrestrial Relationships and the American Geophysical Union.

But, instead, Dr. Bracewell, an Australian, is most decidedly gleeful. He punctuates his remarks with witty commentaries as he swings about in his swivel chair at a desk littered with solar maps, books, and colored slides of his travels and his family. His keen mind is whetted on conversation and his observations of life on this planet are as sharp and all encompassing as his observation of other planets.

He appears to delight in scientific controversy. When asked if long-wave sources have been identified as other than exploding stars or colliding galaxies, he pounced on the term "colliding" galaxies. "There is now a rival theory," he said. "Shklovsky, the Russian scientist, believes they are 'splitting' galaxies, not 'colliding' galaxies." He went on to explain that more and more radio astronomers have noted that the radio sources from known galaxies take on the dumbbell characteristics with the strongest radio signals coming some distance from

(Continued on page 32)

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* *May 28, 1960*

Dr. Bracewell and his interferometer in the Stanford hills.

BRACEWELL

(Continued from page 31)

the galaxy on either end. Shklovsky believes these radio sources are the accumulation of things ejected earlier by the galaxy. As astronomers have observed streams ejecting material from galaxies, Shklovsky believes that these galaxies are splitting rather than colliding.

"This should cause quite a bit of controversy for some time to come," Dr. Bracewell observed.

Instead of listening to discrete radio sounds in outer space, Dr. Bracewell well might have been listening to the chant of wool auctioneers in the Australian wool mart. As he had an early linguistic aptitude, his family considered having him work into the job of wool auctioneer. A knowledge of many languages is necessary on the international wool exchange. But, as Dr. Bracewell explained, he could not see making a livelihood out of language ability.

Though his father was a business man, he had an assiduous interest in science. When Dr. Bracewell eventually professed an interest in chemistry, his father consulted chemists in industry as to the proper training for his son. Dr. Bracewell entered the University of Sydney in the engineering department, explaining that this way he could get chemistry without committing himself and then make a choice.

"After my first year," he said, "I knew I didn't want to be a chemist, that it wasn't as exciting as I had thought. By my second year, my interests had turned to physics and that settled the matter."

Dr. Bracewell proceeded to obtain his BSc in mathematics and physics, his BE in electrical engineering, his masters in communications.

Then during the war, he worked in the Radiophysics Laboratory in Sydney for four years in microwave radar development as Assistant Research Officer. He found working on the short-wave edge of the spectrum fascinating. But when he went to Cambridge to obtain his doctorate, he decided that it would be a nice change to investigate the long waves on the other end of the spectrum. He worked with 20 kilometers and obtained his PhD in Ionospheric Propagation.

The most noteworthy teacher he had during his schooling was Dr. Victor Bailey. "He's a sound physicist, Professor of Experimental Physics at Sydney. But he's most controversial—a man who still produces staggering theories even though he's getting on in years."

When Dr. Bracewell returned from Cambridge to Sydney as Senior Research Officer at the Radiophysics Laboratory, he worked under Dr. J. L. Pawsey. The two men collaborated and produced the book, "Radio Astronomy", which was published in 1955. As Dr. Bracewell remarked, "I am hoping to get a sabbatical this year so that Dr. Pawsey and I can do a revision of the book. It's impossible for us to work together on it, being separated by such distances."

It was during this same period that Dr. Bracewe decided he was "getting on" in age himself (he was his early thirties), and he was not meeting any eligibl women who would make suitable wives in the rarefied atmosphere of outer space.

"So," he grinned, "I joined a square-dancing society in Sydney."

As with most of his projects, he met with early success, the lady in question being a native Australian, Helen

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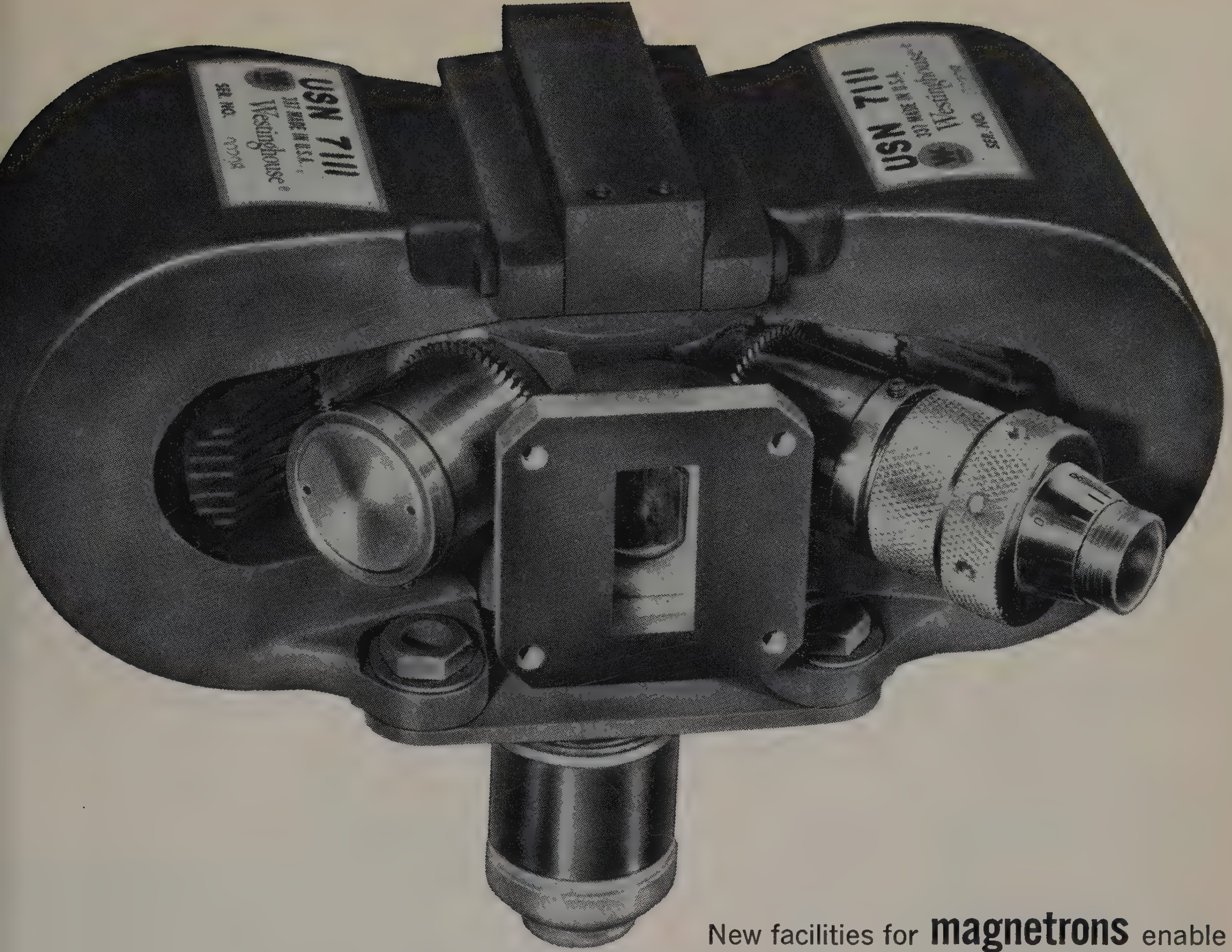

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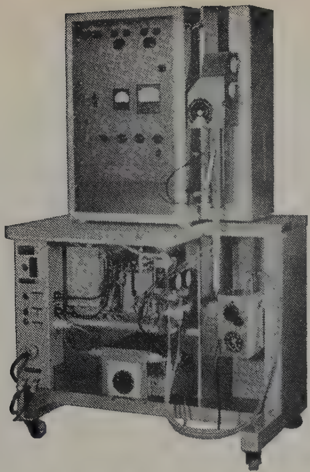

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BRACEWELL

(*Continued from page 32*)

Elliot. "In fact, both of her paternal grandparents were natives, but I had only one pair born in Australia. The other set came from England."

They now have two children, Wendy and Mark, both too young to show any inclinations, scientific or otherwise. In one colored slide of Mark, a husky, three-year old redhead, he is busily pouring a small toy bucket of water into his father's batch of concrete with a most earnest expression. "He's my waterboy when I'm doing patio work," Dr. Bracewell commented with warmth.

On discussing his first impressions of the United States when he arrived at the University of California at Berkeley on a Fulbright scholarship, Dr. Bracewell said, his eyes twinkling, "I'm afraid I made myself unpopular."

I asked him to explain himself. "Well, as you know, one of the first questions Californians ask a newcomer is how they like the climate. Of course, they're used to Easterners coming from snow and cold and raving about the weather. I could only answer them that the climate was much the same as Sydney's, only there is no fog in Sydney. They didn't appear to appreciate my answer."

(*Continued on page 36*)

Graduate student Govinda Swarup of India, assisting Dr. Bracewell, watches adjustment of controls during operation of the 32-dish radio telescope at Stanford.

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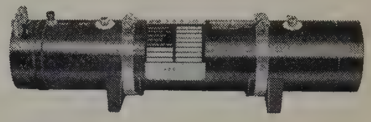

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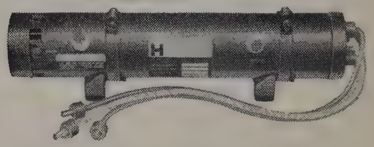

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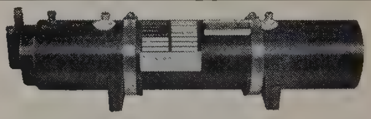

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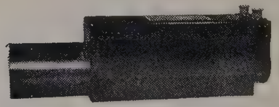

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BRACEWELL

(Continued from page 34)

Shown with the radio telescope are (left to right) Dr. Bracewell's aides, Chi Chrun Lee and Kwang-Shi Yang; Dr. Bracewell; and David A. Cuddaback, University of California astronomer.

It was while at California that he renewed some acquaintanceships at Stanford University and met Mike Villard. Dr. Villard was most interested in the antenna that Dr. Bracewell wanted to build and thought he might be able to interest the Air Force in building the facility at Stanford.

In the meantime, Dr. Bracewell returned to Australia hoping to get the antenna accepted there. "But I found myself out of luck. Two years before going to California I had been busy with my book. Then I was gone for a year. When I returned home, I hadn't worked in experimental radio astronomy for almost three years and all available funds had been expended on other plans."

It was at this moment that Dr. Villard contacted him again and said the plans had been submitted to the Air Force and it looked as if they would be accepted. So Dr. Bracewell returned to the United States to build his interferometer in the Stanford hills.

Dr. Bracewell's antenna is a high-resolution interferometer consisting of two perpendicularly placed rows each of 16 parabolic mirrors, which give a resolution of 3.1 minutes of arc at nine centimeters, equivalent to a paraboloid of 400-foot diameter. When questioned about why he had picked nine centimeters rather than 21 centimeters, Dr. Bracewell said that with the waveguide situation being what it is, you have to pick a size in the beginning and stick with it. Besides, many radio astronomers believe that 21 centimeters is no longer going to be the most important wavelength. In fact, John Bolton

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who constructed the interferometer consisting of two 0-foot steerable paraboloids in the Owens Valley, is strongly of this opinion. Bolton is now in charge of the new 210-foot Australian telescope being built in New South Wales which is due to be completed in May or June of 1961.

Dr. Bracewell says that he hopes to extend his present antenna in the next five years so that it will have much more resolution than the 600-foot dish being constructed in Sugar Grove, West Virginia by the Navy. "Of course, we cannot hope to have the same high gain," he commented.

As an advisor on the 600-foot dish, I asked Dr. Bracewell if it would be finished in 1962 as first scheduled. He shook his head. "I think it will be five more years before completion," he stated. "Costs have gone up from somewhere around 78 million as first estimated to 28 million. They are going to have to ask Congress for more funds."

During his recent visit to Russia as one of two U. S. observers participating in a scientific exchange program sponsored jointly by the U. S. and the Soviet National Science Academies, Dr. Bracewell was specifically interested in the Russian trough-type cross antenna which is to be a kilometer in length when completed and in the 71-foot millimeter-wave dish. He felt that both antennas were outstanding. "I don't believe the Russians are ahead of us in antennas in general, but in these two they are," he noted.

At the moment, Australia, the Benelux countries and Italy have plans on the drawing board for trough antennas, the first two to be somewhat larger than the Russian. "As these antennas will have tremendous penetrating abilities, being able to reach the boundaries of the universe, scientists hope to settle questions as to the formation of the universe with them," Dr. Bracewell remarked.

As for the 71-foot millimeter-wave dish, Dr. Bracewell feels strongly that we must have something in that range which is more adequate than what we now have. Presently, we only possess 10-foot dishes in the millimeter range. As the thermal signals from planetary space are in the shortwave lengths in the millimeter range, he feels it imperative that we have more adequate antennas. He showed me some moon maps made by the Russians with their antennas showing one strong signal on the moon's surface that travels round and around the moon's face at fairly regular intervals.

I asked Dr. Bracewell if he and Dr. Swenson, his fellow scientist on the Russian trip, had seen all they asked to see or encountered any difficulties in observing the objects they were interested in viewing.

"We saw about half the items on our list," Dr. Bracewell answered. "But we gave them a long list. Although transportation is subject to disruption in winter, it seemed to us that more than enough spare time was allowed between activities. But when you consider that due to bad weather we lost three days in Western Europe and were held up in New York for two days by storms on our return here, the allowance was probably reasonable. We never missed any connections in Russia."

(Continued on page 38)

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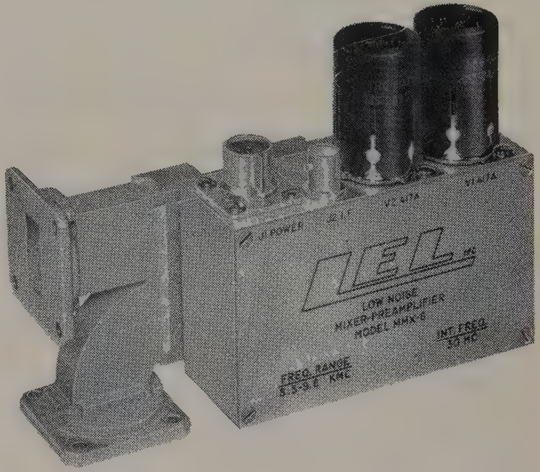

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BRACEWELL

(Continued from page 37)

He went on to add, "I am most impressed by the need to make better contact with people in Russia. I believe it contributes to relaxing some of the political friction. I do look forward to the time when scientists can exchange visits without the necessity of formal agreements beforehand."

He continued by saying that they appeared to have a good supply of young engineers and scientists at the facilities they visited. "Also, things appear to be relaxing even since my last visit there in 1958. More women wear lipstick, the clothing is conspicuously more fashionable—they are even advertising it now. Actually, there is quite a lot of advertising. Take coffee for example. They had an advertisement to the effect that a wife should give her husband coffee in the morning if he is to be alert all day."

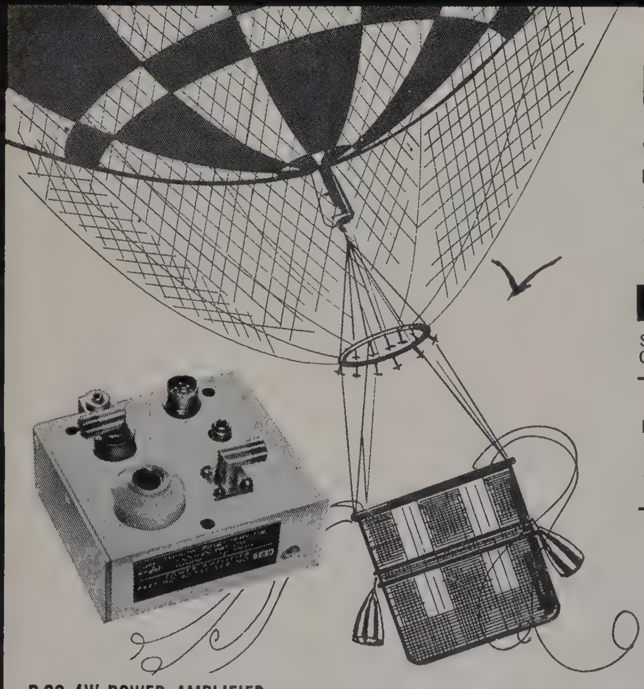
I asked him if he numbered Russian among the languages he had mastered. He laughed. "I've studied it a bit. But you would be surprised at how you lose your diffidence about speaking a language when the only way to get breakfast in your hotel is to order it by phone—in Russian, of course.

"While I was in Russia," he said, "I collected royalties from my book, 'Radio Astronomy', which has sold out the Russian edition." The Russians gave him the money just a few hours before he was to leave the country. Having to spend it there, he madly rushed about buying everything from photographic equipment to an old samovar. "I collected 678 rubles, 50 kopecks in royalties. I am happy to report that I spent the lot," he announced proudly.

Dr. Bracewell said that no specific accomplishment in radio astronomy had given him the most satisfaction. "I'm satisfied most of the time," he said. "I don't ge worked up about things."

On observing Dr. Bracewell, one can see that he i not only a man with scientific curiosity, but a man with curiosity about human motivations. As a radio astronomer, he looks to the stars, to space, for answers to the makeup of the universe and to the possibility of intelligent life in other solar systems. Outside of his profession, he not only looks for better understanding between peoples of the world, but he also works for it during his travels. Speaking the languages of others, being tolerant of the differences between cultures, taking any delays or minor misunderstandings with good humor, Dr. Bracewell in his own way is an ambassador of goodwill.

Definitely, Dr. Bracewell is a man with more vision than his radio telescopes now allow, a man who would never let "sleeping dogs lie" when controversy stirs the minds of men. Still, behind the quick wit and humor of this man is a dedicated scientist whose own star among the astronomers is of the first magnitude—a man who believes our new frontiers are the boundaries of the universe, but who also wants this planet earth to be the best of all possible worlds.



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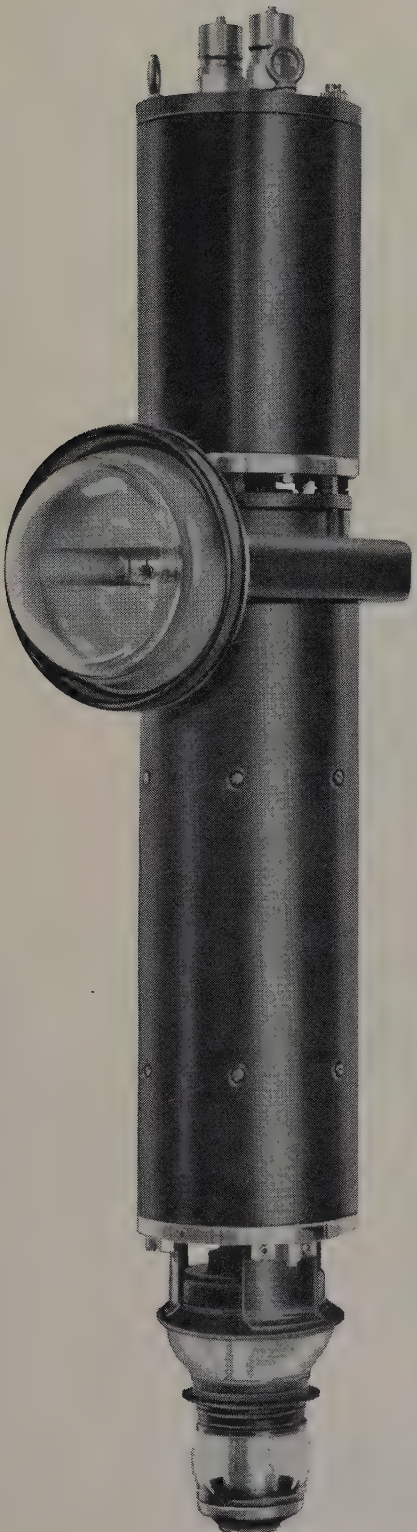

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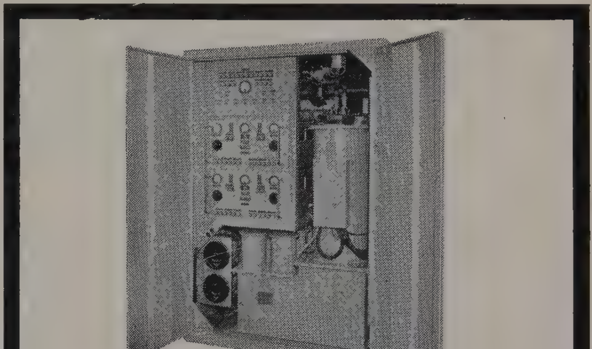

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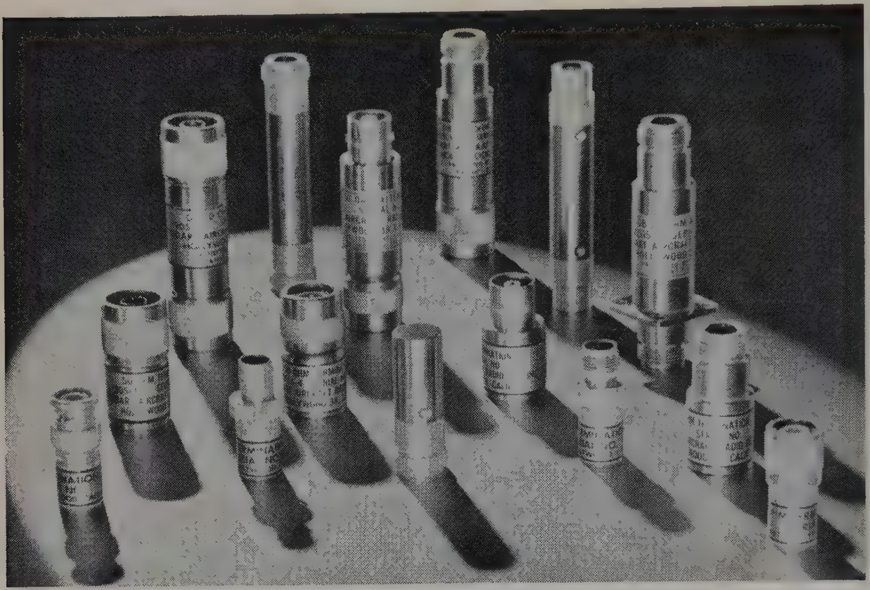

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STODDART
AIRCRAFT RADIO CO., INC.
6644 Santa Monica Blvd., Hollywood 38, Calif. HO 4-9292
serving 33 countries in radio interference control

Industry News

(Continued from page 29)

LOW-ALTITUDE MISSIONS EMPLO PILOTLESS B-47 JETS

Plans to employ pilotless B-47 j bombers in remotely-controlled missio hundreds of miles off the Florida co at extremely low altitudes has been a nounced by Sperry Phoenix Co., divisi of Sperry Rand Corp., Phoenix, Ariz.

Sperry has been awarded an Air For contract to equip the unmanned B-47's – termed QB-47 drones — for realist testing of the nation's SAGE air defen network.

Key to the low-altitude missions of th multi-jet drones is a radar comman guidance-telemetry system developed Sperry with the Air Force's Wright A Development Division, Dayton, Ohio. is the first such system designed to co trol many types of pilotless craft at bot high and low altitudes, and it employ a unique GC-130 aircraft as a sort "flying command post" for the QB-4 missions.

Among the aspects of the Sperry syste is the use of a single radar frequen band (X-band) for all command an telemetering functions. It thus does th job of a multiplicity of individual sy tems previously needed for the variou portions of a complete drone mission.

—*mwj*—

MAGENHEIM NAMED CHIEF ENGINEER

Bertram Magenheim has been name Chief Engineer of Control Electron Co., Inc., Huntington Station, N. Y., it has been announced by Alfred C. Walker, president.

In his new post, Mr. Magenheim will direct all of the engineering activities of the company in the microwave, delay line, audio filter and instrument fields. Prior this promotion, he was head of the co pany's microwave division.

Before joining the company, Mr. Mage heim was associated with RCA, Polar Electronics, FXR, and Raytheon Manufa turing Co.

He holds a BEE from College of t City of New York, and has also do graduate work in electromagnetic theor microwave, network theory and vect analysis at Northeastern University a Polytechnic Institute of Brooklyn. He a member of Eta Kappa Nu and the Ins tute of Radio Engineers.

—*mwj*—

(Continued on page 42)

Circle Reader Service Card 30

NOW THIS VERSATILE PULSE MODULATOR IS AVAILABLE OFF-THE-SHELF

adiation at Stanford (formerly Levinthal) apabilities in modulators are widely recogized. These quality standards are fully maintained in the odel 344M, a hard-tube pulser for klystrons, TWTs and agnetrons that affords maximum application flexibility.

But this is the news . . . The Model 344M is now available from stock; your crash program needn't wait on a stom-built modulator.

Here are a few specifications on the Model 344M Pulse Modulator:

· Peak power output	1.2 megawatts
· Peak pulse voltage and current	0-40kv, 0-30a to 5,000 pps 0-30kv, 0-30a to 10,000 pps
· Pulse width (90%)	0.1-5.0μsec continuously variable
· Maximum duty cycle	.002

For technical and performance data, write Radiation at Stanford, 3180 Hanover Street, Palo Alto, Calif.

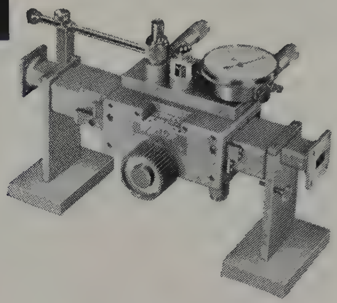
RADIATION
at Stanford
Formerly Levinthal Electronic Products Inc.

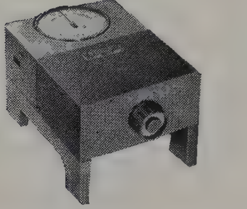
Circle Reader Service Card 31

Precision Measurement Demands

QUALITY MICROWAVE

instruments





ATTENUATORS
SLOTTED LINES
WAVEGUIDE COUPLERS
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FREQUENCY METERS
PHASE SHIFTERS
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PRECISION TUNERS
NOISE SOURCES
TRANSITIONS
GAIN HORNS
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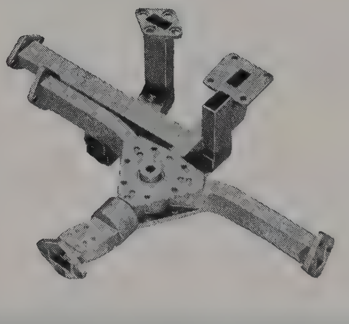
and components



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Consult Waveline in order to achieve maximum compliance with your complex waveguide requirements. Standard instruments and special components are available.

WAVELINE INC.
CALDWELL, NEW JERSEY
Phone: CApital 6-9100
TWX Caldwell, N. J. 703

Circle Reader Service Card 32

(Continued from page 40)

SYLVANIA NAMES LaMONTAGNE MARKETING MANAGER

The appointment of Ralph S. LaMon tagne as marketing manager of the Wal tham Laboratorie of Sylvania Elec tronic Systems Waltham, Mass., division of Sylvani Electric Produc Inc. has been an nounced by Richard M. Osgood, gene manager of th laboratories.

Prior to joinin Sylvania, Mr. LI Montagne was manager of marketing the Missile Electronic and Control Div sion, Radio Corporation of Americ Burlington, Mass. Earlier, he served i the same capacity for RCA's Airborn Systems department, Moorestown, N. J.

Mr. LaMontagne is a graduate of th University of Maryland with a bachelo degree in military science. He has als attended Massachusetts Institute of Tech nology and Boston University.

A senior member of IRE, he is a mem ber of the board of governors of th Lexington-Concord (Mass.) chapter the Armed Forces Communications an Electronics Association, Air Force Asso ation, and Association of the United Stat Army.

—mwj—

VITRO AND SELENIA FORM ITALIAN COMPANY

Vitro Corporation of America an Selenia S.p.A., a Raytheon Compan subsidiary, have formed a new compan in Italy for the design and installation missile systems and other electroni equipment. This was jointly announce by Vitro in New York, N. Y. and Ray theon in Boston, Mass.

The new company will be known Vitroselenia and will be headquartere in Rome. Predicted combined sales vo ume for the first three years of operatio will total about $14-15 million, accordin to company officials.

Vitro and Selenia will each have a ha interest in the new firm and each wi provide three of the six directors of V troselenia. Raytheon vice president D Carlo L. Calosi, who is Manager of Ray theon (Europe) A.G. and managin director of Selenia, and Dr. Norman A Spector, vice president of Vitro Corpora tion and president of Vitro Internationa are among the six Board members.

Selenia is the largest of the Raytheo Europe group of companies.

—mwj—

(Continued on page 44)

PROGRESS IN MICROWAVES

New General Electric VTM's and TWT's . . .

ADVANCE S- AND X-BAND TRANSMITTER CAPABILITIES

Provide Higher Power in Lighter, Smaller Tubes

Four new General Electric power tubes—two voltage-tunable magnetrons and two traveling-wave tubes—have been designed to advance transmitter capabilities in S- and X-bands. All provide higher power in smaller, lighter, more compact packages for missile and airborne transmitter applications.

HIGH EFFICIENCY, LIGHT WEIGHT VTM's

Designed primarily for space applications, the Z-5428 voltage-tunable magnetron achieves an efficiency of 35 percent in a tube weighing only 4.5 pounds. Moreover, it operates under severe shock and vibration conditions with only radiation cooling. Tests show the Z-5428 meets shock requirements of 40 G's for 11 milliseconds and vibration requirements of 5 to 25 cps at one quarter-inch double amplitude; and from 25 to 2000 cycles at 10 G's.

Equally efficient and compact, the Z-5424 provides high power (50 W min.) in an exceptionally light (4.5 pounds) VTM. And like the Z-5428, it is a complete r-f power package requiring only input and r-f output power connections.

Both VTM's can be linearally voltage-tuned without mechanical adjustment.

HIGH-POWER, COMPACT TWT's

The two new high-power traveling-wave tubes are designed to operate in series, one as the driver and one as the final amplifier in a pulsed high-power chain for X-band radar applications. They are compact, of metal-ceramic construction, and incorporate an advanced focusing system utilizing periodic permanent magnets requiring no temperature stabilization. The Z-3090 driver tube weighs only 15 pounds while the Z-3091 amplifier tube weighs 42 pounds with electrical connectors. Both tubes are ruggedized for airborne applications and can be mounted in any position.

These TWT's, as well as the new VTM's, are now available in sample quantities. Delivery in 90 to 120 days.

265-06

FREQUENCY RANGES AVAILABLE*

VTM's OSCILLATOR SERVICE

Frequency (KMC)	P_0 (Min. CW)
2.2 – 2.3	10 W
2.5 – 3.5	10 W
2.9 – 3.2	50 W
5.17 – 5.42	10 W

TWT's AMPLIFIER SERVICE

Frequency (KMC)	P_0 (Min. Peak)
5.4 – 5.9	25 KW
8.5 – 9.6	5 KW
8.5 – 9.6	50 KW
8.5 – 9.6	250 KW

**These tubes can be scaled to meet specific frequency and power requirements.*

TO ORDER, or obtain more information, contact your nearest Power Tube Sales office (telephone numbers listed below).

POWER TUBE DEPARTMENT

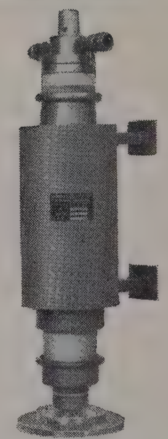
GENERAL ELECTRIC

TELEPHONE TODAY—Syracuse, OL 2-5102 . . . New York City, WI 7-4065 . . . Clifton, N. J., GR 3-6387 . . . Washington, D. C., EX 3-3600 . . . Chicago, SP 7-1600 . . . Dayton, BA 3-7151 . . . Orlando, Fla., GA 4-6280 . . . Los Angeles, GR 9-7765

Circle Reader Service Card 33

Z-5424: 50 percent efficiency—2900 to 3200 mc.

Z-5428: Designed for space—2200 to 2300 mc.



Z-3091: Periodic permanent-magnet focus high-power traveling-wave tube

LOOK TO G-E POWER TUBE DEPARTMENT FOR:

- Ignitrons
- Hydrogen Thyratrons
- Magnetrons
- Metal-ceramic Tetrodes
- High-power Duplexers
- Klystrons
- Thermionic Converters
- Traveling-wave Tubes
- Harmonic Filters

MICROWAVE MANAGER

This ferrite phase differential circulator is an Airtron device for managing microwaves in X-band. It was specifically designed to meet the requirements of very high power systems operating at 2 megawatts of peak power and 1500 watts of average power over a frequency band of 8500 to 9600 Mc/s while pressurized at 3 atmospheres. Used as a duplexer, with its fourth arm terminated in a dummy load, this water cooled unit provides 20 db isolation between channels. Others are available for Ka through S bands in both aluminum and brass constructions.

With modifications, these ferrite circulators have been used as diplexers, discriminators, isolators, and switches. Let us work with you, or quote, on the specific configuration for *your* application. Or, write for additional information.

AIRTRON
A DIVISION OF LITTON INDUSTRIES

AIRTRON-MORRIS PLAINS • 200 EAST HANOVER AVENUE, MORRIS PLAINS, N.J.
GENERAL OFFICES AND ADVANCED DEVICES LABORATORIES, MORRIS PLAINS, N.J.

Circle Reader Service Card 34

(Continued from page 42)

LENKURT TO FILL AIR FORCE ORDERS

Lenkurt Electric Co., Inc., San Carlo Cal., has received orders from the U. S Air Force for 16 mobile 60-channel mu tiplex terminals valued at an estimat $3 million.

The orders came from the Rome Ai Materiel Area at Griffiss Air Force Bas Rome, New York.

The terminals are the tactical versi of the fixed-office 600-channel AN/FCC 17 multiplex system, for which Lenku has been prime development contract with the Rome Air Development Cente since 1958. AN/FCC-17 was conceive by the Air Force as the universal standar multiplexer for its huge 480L globa communications program.

To fit its role in networks all ove the world, AN/FCC-17 will handl voice, data, or graphics on any channe without channel selection or special adjus ment. And although particularly designe for point-to-point radio, the system ma be adapted to work equally well o open-wire or cable.

—*mwj*—

STORER NAMED TO SYLVANIA POST

Dr. James E. Storer has been name acting director of the Applied Researc Laboratory of Sy vania Electri Products Inc., Wa tham, Mass.

Dr. Storer r places Dr. Leonar S. Sheingold, whos appointment a chief scientist o the U. S. Air Forc was announce recently by Gene al Thomas White, Air Force Chief of Staff. The chie scientist appointment is made for a on year period.

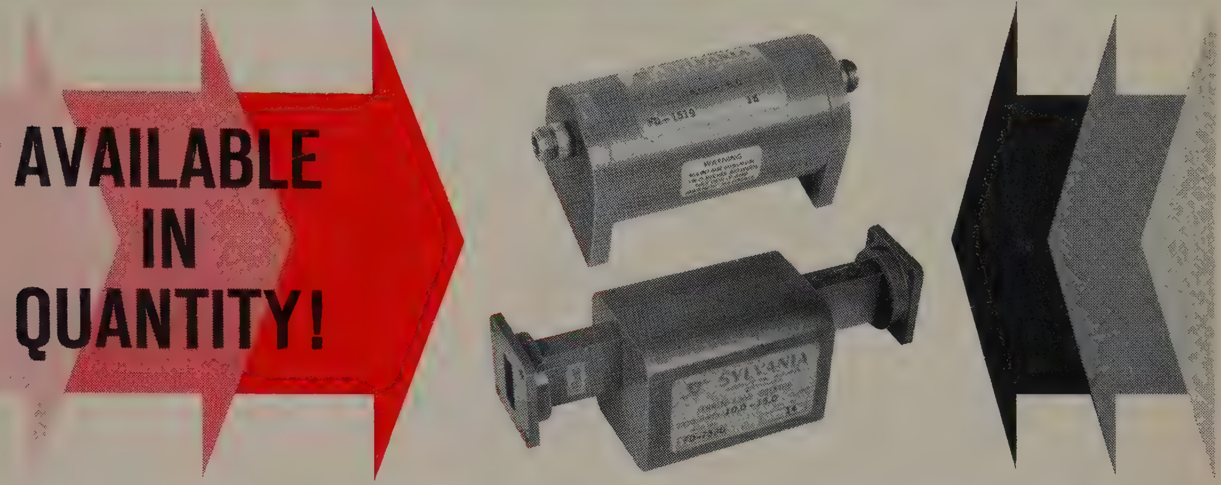
Dr. Storer formerly served as a seni scientist. In 1960, he was one of the fir two appointees to that position withi GT&E. Prior to joining Sylvania in August, 1957, Dr. Storer served as a consul ant to the Applied Research Laborator performing studies relating to militar systems analysis.

Dr. Storer's subsequent work at th laboratory has included fundamental research in signal analysis and data proces ing. He has investigated novel digit codes for radar and communications usin advanced mathematical techniques. H major contribution has been the synthes and analysis of new types of digital da communication systems.

—*mwj*—

(Continued on page 46)

MICROWAVE DEVICE NEWS from SYLVANIA



BROADBAND FERRITE ISOLATORS

COAXIAL DEVICES / WAVEGUIDE DEVICES

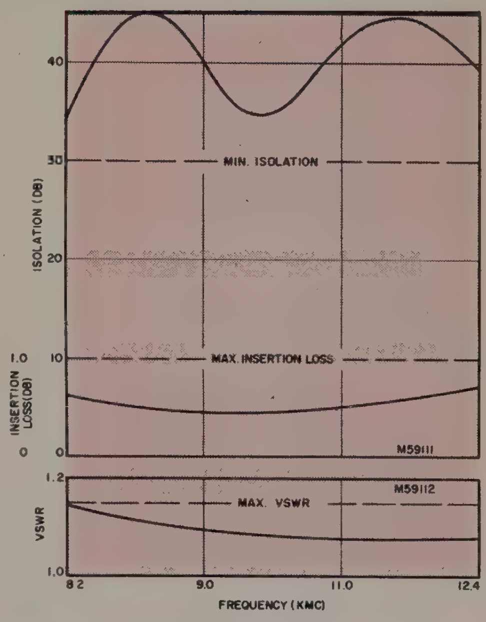
—from 1-11 GC / *—from 3.95-26 GC*

lvania offers a comprehensive line of coaxial and waveguide isolators— types, in all—featuring extraordinary isolation to insertion loss ratios as gh as 30 to 1. Designed for wideband applications in such end-products ECM and laboratory test equipment, they're extremely well suited for e reduction of VSWR and the elimination of anomalies caused by long e effects in oscillator outputs.

our Sylvania Sales Engineer will be pleased to tell you more about the l line of *competitively priced* broadband coaxial and waveguide isolators. k him. For technical data, write Electronic Tubes Division, Sylvania ectric Products Inc., 1100 Main St., Buffalo 9, N. Y.

BROADBAND COAXIAL ISOLATORS Frequency	Types	Isolation (Min.) (db)	Insertion Loss (Max.) (db)	VSWR
1.0-2.0	FD-1537	10	1.2	1.2
2.0-4.0	FD-151P	15	1.0	1.2
4.0-8.0	FD-1519	10	1.0	1.25
8.0-11.0	FD-1522W	30	1.0	1.4
BROADBAND WAVEGUIDE ISOLATORS				
3.95-5.85	FD-492	18	1.0	1.15
5.85-8.2	FD-502	20	1.0	1.15
7.05-10.0	FD-512	24	1.0	1.2
8.2-12.4	FD-522	30	1.0	1.15
10.0-15.0	FD-7530	30	1.0	1.15
12.4-18.0	FD-911	24	1.0	1.15
18.0-26.0	FD-531A	24	1.0	1.15
18.0-26.0	FD-531AF1	24	1.0	1.15

Typical performance characteristics of FD-522



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GENERAL SYSTEM

COAXIAL
BROAD
BAND
FERRITE
ISOLATORS

IN SIZES FOR EVERY APPLICATION

Now—from Kearfott, a new and broader line of Ferrite Isolators to satisfy the most exacting requirements of band width and isolation. Combining low unit loss characteristics with compactness and light weight, this new series of Kearfott Coaxial Isolators is available from present stock. Immediate selection and faster delivery is assured *...precision performance proven.*

A FEW OF THE TYPICAL SPECIFICATIONS

MODEL	FREQUENCY	ISOLATION	INSERTION LOSS	VSWR
C991100-402	1.2—2.6 KMC	10 DB Min.	1.0 DB Max.	1.20
C992100-405	2.0—2.5 KMC	30 DB Min.	.8 DB Max.	1.20
C992100-404	2.0—4.0 KMC	10 DB Min.	1.0 DB Max.	1.20
C992100-407	3.0—3.5 KMC	35 DB Min.	.8 DB Max.	1.20
C993100-401	4.0—8.0 KMC	10 DB Min.	1.0 DB Max.	1.20
C994100-403	7.0—9.0 KMC	25 DB Min.	.8 DB Max.	1.20

Complete information on these or all of the models is available by directing inquiries to: 14844 Oxnard Street, Van Nuys, California, or the sales office in your area.

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

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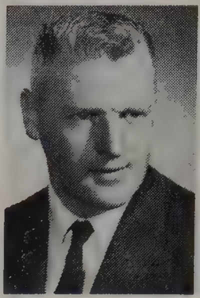
Circle Reader Service Card 35

Industry News

(Continued from page 44)

KNOOB APPOINTED TO MOTOROL STAFF

Gordon B. Knoob has been appointed the position of staff engineer in the pr gram planning d partment of th Western Center Motorola's Milita Electronics Di sion, Scottsda Ariz., it was a nounced by Harv M. Ross, progra planning manage



In his positi Knoob will be r sponsible for th development of new program and produ areas in the field of aerospace activiti This work will include the analysis an organization efforts required to mat Motorola's capabilities to the space age.

Knoob draws from 18 years' experien in military electronics. Prior to his cu rent assignment he managed the west coa regional marketing activities for Moto ola's Military Division in Hollywoo Cal.

His electronics career, following grad ation from Pomona College with a B degree in Physics in 1942, includes fo years as a member of the senior technic staff at the Motorola Systems Resear Laboratory in Riverside, Cal.

—mwj—

CONFERENCE SET ON AEROSPAC AND NAVIGATIONAL ELECTRONICS

The Baltimore Section and the Profe sional Group on Aerospace and Navig tional Electronics have scheduled th Eighth East Coast Conference for Octob 23-25, 1961, at the Lord Baltimo Hotel, Baltimore, Maryland.

The conference will emphasize eng neering developments, electronic tec niques, and scientific accomplishmen related to missiles, aircraft, and spac vehicles. Fields of interest include co munications, telemetry, ground suppo equipment, computers, spectrum utiliz tion, interference considerations, dat handling, radar, microwaves, antenna air traffic control, navigation, propag tion, microminiaturization, etc. No e hibits are planned so attendees ca devote themselves completely to th technical sessions.

The East Coast Conference Award $100 will be presented to the author the best unclassified paper. A secon prize of $50 will also be awarded. I order to qualify for awards, the complet paper must be received by Septemb 1, 1961. Papers received as abstracts onl or received after September 1, 1961, wi not be eligible for award and cannot b published in the Proceedings of the co erence which will be distributed at the meeting.

The deadline for abstracts has been extended this year to July 5, 1961. Three copies of 500-word abstracts of papers for the unclassified sessions should be sent to: William C. Vergara, Director Advanced Research Department, Bendix Radio, Towson 4, Maryland together with a brief professional record of the author. Speakers should plan on 20 minutes for the presentation of each paper and 10 minutes for discussion.

—*mwj*—

LFE NAMES GENERAL MANAGER

Edwin D. Campbell, vice president and treasurer of Laboratory For Electronics, Inc., Boston, Mass., has been elected to the new office of vice president and general manager. He will direct all LFE operating and administrative divisions which now employ over 2700 people.

Succeeding Mr. Campbell as treasurer will be David A. Shuntz, assistant treasurer for the corporation since 1959.

Mr. Campbell joined LFE in 1953 as corporate controller. In 1955 he was appointed treasurer and was named a vice president of the company and elected to the board of directors in 1956.

A graduate of the Bentley School of Accounting and Finance, Mr. Campbell is a director of the Associated Industries of Massachusetts and a member of both the Massachusetts Society of Certified Public Accountants and the American Institute of Certified Public Accountants.

—*mwj*—

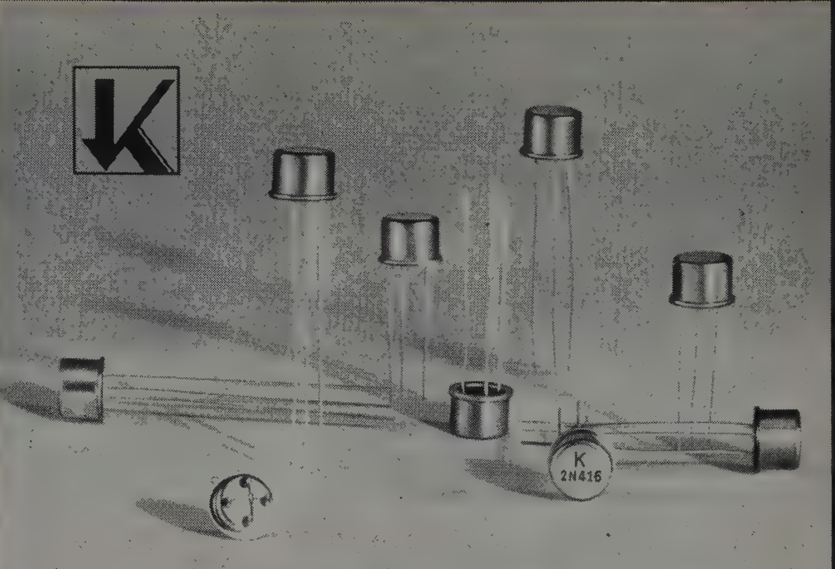
ELECTRON TECH POSITION FILLED BY LeVINE

Stanley J. Koch, president of Electron Technology, Inc., Kearny, N. J., designers and manufacturers of power and special purpose tubes for the electronics industry, has announced the appointment of Harris D. LeVine of Totowa, N. J. to the position of assistant to the president.

Mr. LeVine joined the Kearny firm with 20 years experience in the field of power and special purpose tubes. He was formerly director of the Instrumentation Division of Health and Safety Laboratories for the Atomic Energy Commission for 13 years.

Mr. LeVine was also Senior Chief Engineer of the X-ray Tube Section of North American Philips. He spent several years as Senior Microwave Tube Engineer at National Union. The appointment of Mr. LeVine is part of the major expansion program now under way at Electron Technology, Inc.

—*mwj*—



KEARFOTT TRANSISTORS PROVIDE HIGH RELIABILITY-CONSISTENT PERFORMANCE

HIGHEST POWER DISSIPATION OF ALL AVAILABLE GERMANIUM-ALLOY JUNCTION TRANSISTORS

Kearfott now offers a complete off-the-shelf series of TO-5 germanium-alloy PNP junction transistors. Their unexcelled electrical and mechanical reliability, precise electrical characteristics, and virtual insensitivity to temperature changes derive from Kearfott's intensive materials-and-methods control, plus complete, 100% functional testing. These factors add up to the consistent reliability, uniformity, extended service life, and repeatability of product performance which typify Kearfott semiconductors.

DESIGNED AND PRODUCED BY KEARFOTT SEMICONDUCTOR CORP. WEST NEWTON, MASS.

CHARACTERISTICS

Meet or exceed requirements of NAVORD OS9669B (R-212 Series) and MIL-S-19500B

All transistors tabulated below are available with maximum collector power dissipation of 200 mw.

2N123
2N315
2N315A
2N316
2N316A
2N317
2N317A
2N394
2N395
2N396
2N396A
2N397
2N404
2N404A
2N413
2N414
2N414A
2N416
2N425
2N426
2N427
2N428
2N519
2N520
2N520A
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2N578
2N579
2N580
2N581
2N582
2N653
2N658
2N659
2N660
2N661
2N662
2N1017
2N1303
2N1305
2N1307
2N1309

Write for complete data

KEARFOTT DIVISION
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Little Falls, New Jersey

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3 WATTS at 1120 Mc from 7 WATTS at 140 Mc

A VARACTOR FOR EVERY PURPOS

220 new epitaxial silicon high power varactors i four package styles — subminiature glass case double-ended cartridge • "pill" case • new "coaxia pill" case — all hermetically sealed, make *this* kin of harmonic generation possible now.

A WIDE VARIETY of PIV ratings and capacitan values allows selection of the optimum diode in ea case style for your circuit application.

The data reported below was obtained by the Waveguide Systems Division of Microwave Associates in a tandem chain of three doubler stages, eac using a selected single Microwave Associates' epitaxial silicon high power varactor.

This high power output and remarkable harmoni efficiency was achieved without boosters, withou power supply, in passive circuits.

Since the initial introduction of varactors on commercial basis by Microwave Associates, we hav continued to lead the way in varactor technology

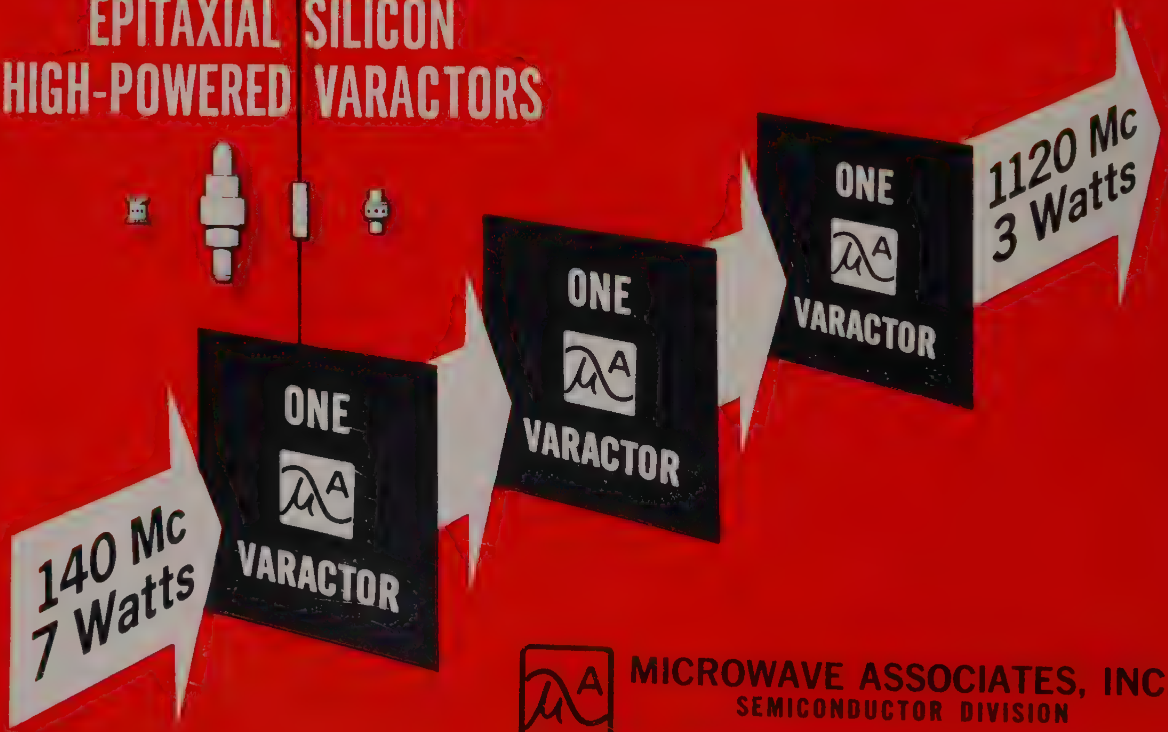
Microwave Associates' unsurpassed varactor circui capabilities are your assurance of varactors teste to meet specific harmonic generation requirements

The Waveguide Systems Division of Microwave Associates offers capabilities for the design and delivery of complete harmonic generator circuits.

Write for a copy of "SELECTION OF VARACTORS FOR POWER HARMONIC GENERATION and for the 1961 Semiconductor Division Shor Form Catalog.

* Support received by (USAF) ETL Aeronautical Systems Division Contract #AF33 (616) — 7232.

with MICROWAVE ASSOCIATES EPITAXIAL SILICON HIGH-POWERED VARACTORS



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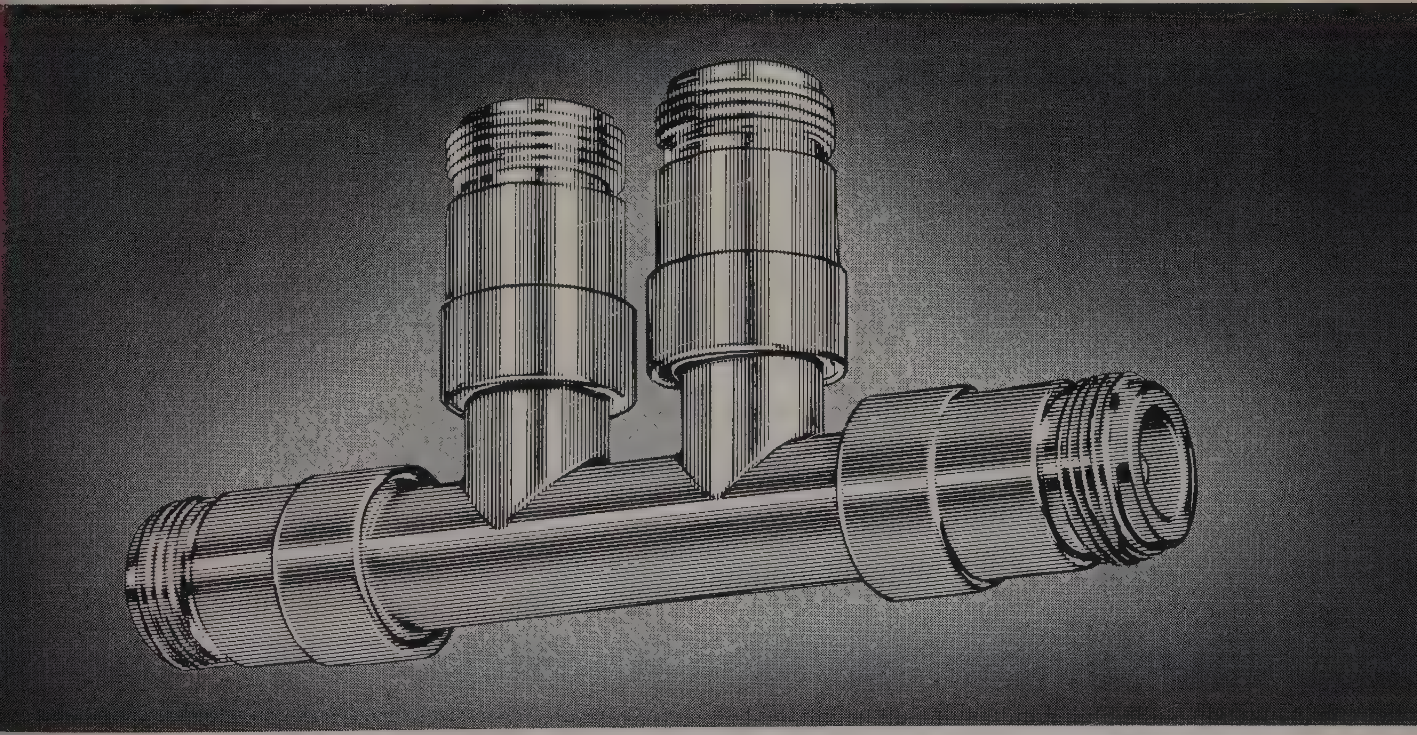
DIRECTIONAL COUPLERS NOW AVAILABLE IMMEDIATELY FROM MICROLAB

MICROLAB OFFERS THE BROADEST LINE OF DIRECTIONAL COUPLERS AVAILABLE FROM STOCK.

THE CA, CB, CC, CE, CF, CG AND CH SERIES ARE AVAILABLE IN 42 STANDARD FREQUENCY RANGES FROM 200 MC TO 4000 MC WITH N, BNC, TNC AND C SERIES CONNECTORS. THE TUBULAR DESIGN ASSURES A SMALLER PACKAGE WITH LIGHTER WEIGHT FOR USE IN LABORATORY, PRODUCTION TESTING OR MICROWAVE SYSTEMS. MODIFICATION OF THE STANDARD COUPLERS AND/OR CONNECTORS ARE AVAILABLE ON REQUEST. WRITE FOR CATALOG 10A.



MICROLAB

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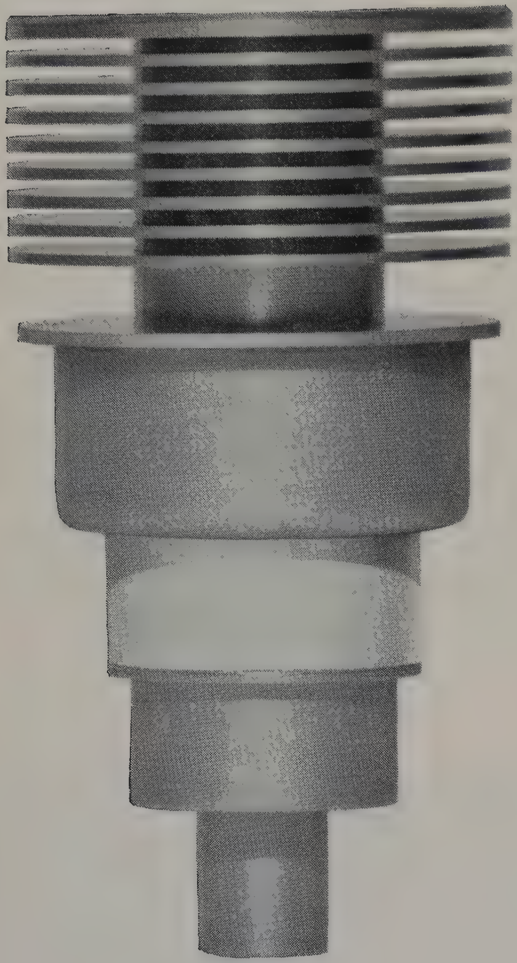

UHF

Frequency Stable

CW or Plate-Pulse

ML-7855

Ceramic Planar Triode

Special anode design of ML-7855 permits frequency stable operation within 10-15 secon after application of high voltage. (Frequency change during this initial period is within 1 mc

ML-7855 provides frequency stable operation with unregulated supply, as change of pla dissipation has no effect on change of frequency.

CW operation to 2500 Mc, with 1000 V Ebb, 100 ma Ia.

Plate-pulsed to 3000 Mc, with 3500 v eb, 3.0 a ib, with a tp of 3 usec at 0.0025 Du.

Send for Machlett UHF Planar Tube Brochure

MACHLETT

Subsidiary of Raytheon Company

The Machlett Laboratories, Inc.
Springdale, Connecticut

CONTRIBUTORS IN THIS ISSUE

RANKLIN W. BARR was born in Hartord County, Maryland in 1935. He received the BS degree in aero- utical engineering in 1957 and the BS degree in meteorology in 1959, both from Pennsylvania State Uni- ersity. At the present time he is a candidate for the MS degree in aeronautical engineering at the ennsylvania State University.

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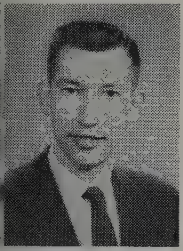

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MICROWAVE PROPERTIES OF POLYCRYSTALLINE HYBRID GARNETS

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I. Introduction

Ferrimagnetic garnet materials have provoked much interest since their discovery,[1,2] especially for their application in microwave devices. This interest has led to very intensive studies on the crystallographic, magnetic, and other fundamental properties of these materials.

Approximately one-half[3] of the metal ions in the periodic table have been put in the crystal structure of garnets, but of these only a few are ferrimagnetic above room temperature. Of the ferrimagnetic garnet compositions derived, yttrium-iron garnet is by far the most useful for microwave applications. In this study yttrium-iron garnet was used as a basic composition to investigate the microwave properties of a number of polycrystalline mixed garnets. The compositions investigated include solid solutions of yttrium-iron garnet with gadolinium-iron,[4,5,6] samarium-iron,[4, 6, 7] yttrium-aluminum,[8, 9] yttrium-gallium,[8,10,11] and yttrium-chromium[8] garnets. The magnetic and crystallographic properties of these materials have been studied by many investigators. Less has been reported on resonance properties, temperature characteristics, and high power response of these materials. In this work the microwave properties (magnetization, linewidth, Curie temperature, and g-factor) have been studied primarily from an engineering standpoint. This leads necessarily to an investigation of temperature characteristics and high power phenomena.

TABLE I: Structural Properties of the Substituted Ions

ION	LATTICE SITE PREFERENCE IN GARNETS *			NO. OF UNPAIRED ELECTRONS	IONIC RADII A° ** (AV. VALUES)
	↓ 16a	↓ 24c	↑ 24d		
Y^{+++}		1.0		0	0.95
Fe^{+++}	0.4		0.6	5	0.66
Gd^{+++}		1.0		7	1.04
Sm^{+++}		1.0		5	1.00
Al^{+++}	.1 ∓ .05		.9 ± .05	0	0.51
Ga^{+++}	.1 ∓ .02		.9 ± .02	0	0.62
Cr^{+++}	1.0			3	0.64

* *R. Pauthenet, Compt. Rend. 243, 1737 (1956).*
M. A. Gilleo and S. Geller, Phys. Rev. 110, 73 (1958).

** *Goldschmidt, Pauling, Zachariasen, Ahrens.*

The structural configuration of the metal ions substituted into the garnet structure is very important in predicting the microwave properties of the materials. Table I shows some of the structural properties of the metal ions substituted in this work. This table lists the various metal ions substituted, the fractional site preference in the structure for each of these ions,‡ th number of unpaired electrons per ion‡‡, and the average ionic radii. The lattice site location is in part determined by the size of the ion. In yttrium-iron garnet, $3Y_2O_3 \cdot 5Fe_2O_3$, all of the yttrium ions are located on the 24c sites and the iron ions (ten per formulae unit) are split between the other two sites (six on the 24d site and four on the 16a site). Gadolinium and samarium ions prefer the same site as yttrium. Gallium and aluminum ions, both smaller in size than iron, locate primarily on the 24d site, which is the smaller of the two iron sublattices. Even though chromium is smaller than iron it prefers the 16a site presumably because of its electronic configuration.

Essentially all of the microwave properties of ferrimagnetic garnet materials can be interpreted from the standpoint of ionic location in the crystalline structure. There exists a strong anti-parallel (anti-ferromagnetic) interaction between the ions on the 16a and 24d sites and a weaker, also anti-ferromagnetic, coupling between the 24c and 24d sites as indicated by the arrows in Table I.

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‡ *The three lattice sites available for metal ions in the structure are known as the 16a, 24c, and 24d sites.*

‡‡ *These unpaired electrons determine the magnetic moments per ion.*

These interactions between the magnetic moments of the metallic ions concerned can be used to explain the magnetization of the material. According to Neel[12], a simple algebric sum of these magnetic moments should predict the magnetization. Curie temperatures are primarily determined by the number of iron-iron interactions[8]. According to the theory of Kittel[13], linewidths are controlled predominantly by the ion located in the 24c site; the iron and rare earth ions both contribute to the g-factor of the material.

II. Materials Preparation and Measurement Equipment

A one-fourth mole batch of the oxide ingredients (high purity and reagent grade oxides were used throughout)‡‡‡ was mixed with water in stainless steel ball mill jars containing stainless steel balls. After mixing and vacuum filtering the material was dried, screened, placed into platinum dishes and presintered at approximately 1200°C. After suitable lubricant (water) and binder had been added, the presintered powder was pelletized and dry-pressed into discs approximately one inch in diameter by 1/4 inch high. The discs were fired between 1400 and 1450°C in a muffle type silicon carbide element furnace containing an oxidizing atmosphere.

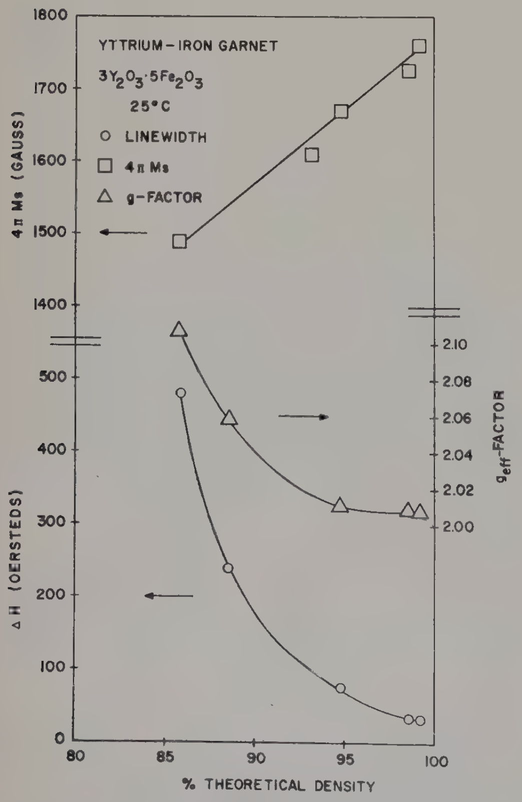


Figure 1 — Variation of linewidth, saturation magnetization and effective g-factor with density for a yttrium-iron garnet.

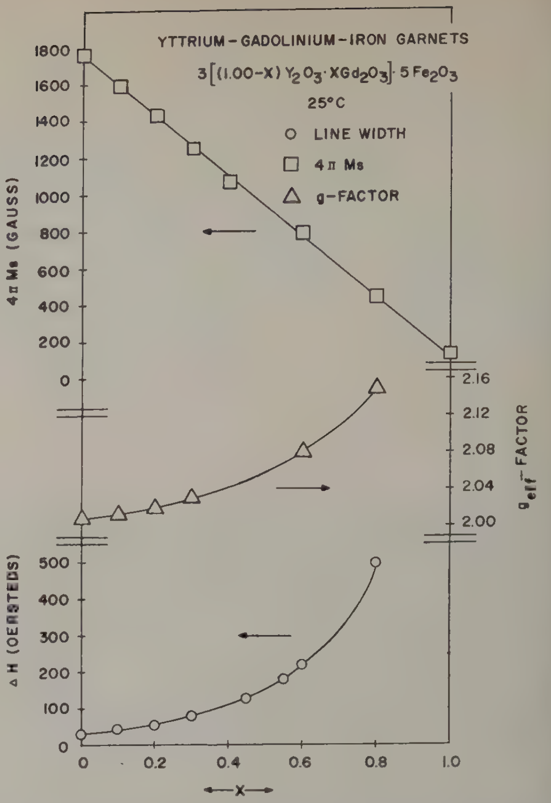


Figure 2 — Variation of linewidth, saturation magnetization and effective g-factor with gadolinium content in yttrium-gadolinium-iron garnet.

The bulk densities of all samples were greater than 9 per cent theoretical X-ray density unless otherwise noted. Chemical analysis of the garnet samples revealed very little iron pick up due to the preparation procedure.

Linewidth, g-factor, and temperature measurements were made on sphere samples (20±2) mils in diameter using a reflection type X-band cavity[14]. All samples had 4/0 surface finishes. Saturation magnetization data were collected on sphere samples approximately 50 mils in diameter using a pendulum magnetometer[15] calibrated with pure nickel and pure iron spheres. High power measurements were made on sphere samples (30±1) mils in diameter in an X-band transmission cavity[16].

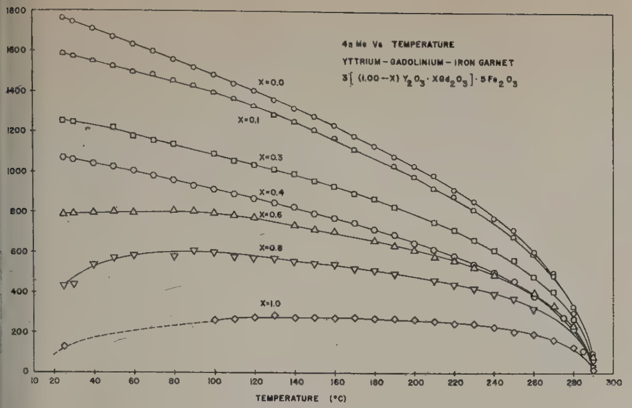
III. Results and Discussions

In addition to ionic substitutions, the microwave properties of the materials may be controlled somewhat by the ceramic treatment given the material. Figure 1 shows how the properties of yttrium-iron garnet can be varied by controlling the density of the material. It should be noted that the linewidth is a very strong function of density. In fact, all of the properties vary somewhat with density.

Partial substitutes of gadolinium and samarium for yttrium are quite interesting, particularly from the standpoint of the temperature characteristics of their magnetization. Gadolinium has seven unpaired electrons, and thus from Neel[12] theory gadolinium-iron garnet has a magnetic moment of *32 Bohr magnetons per formula unit at 0°K.* However, the magnetic moment of the gadolinium ions relax much faster as a function of temperature than do the iron ions producing a compensation point at approximate-

---

‡‡‡ *Raw materials used were as follows:* Fe_2O_3, *99.4 per cent pure, C. K. Williams Co.;* Al_2O_3, Cr_2O_3, *99.4 per cent pure, Baker Analyzed Reagents;* Ga_2O_3, *99.99 per cent pure, United Mineral and Chemical Corp.;* Y_2O_3, Gd_2O_3, Sm_2O_3, *99.9 per cent pure, Lindsay Chemical Division of American Potash and Chemical Corp.*



igure 3 — Variation of saturation magnetization with temperature for mixed yttrium-gadolinium-iron garnet.

15°C. Variation of magnetization, linewidth, and g-fac-
or with gadolinium content for mixed yttrium-gadolinium-
on garnets is shown in Figure 2. Variations in line-
idth and magnetization are observed since gadolinium
cates in 24c site in the structure. At room temperature
newidths remain essentially constant up to around 25
er cent substitution of gadolinium while magnetization
ecreases steadily according to the per cent of gadolinium
ubstituted. The g-factor increases as higher gadolinium
ubstitutions are made. Figure 3 shows the variation of
agnetization of these yttrium-gadolinium garnets as a
unction of temperature. No change in the Curie tem-

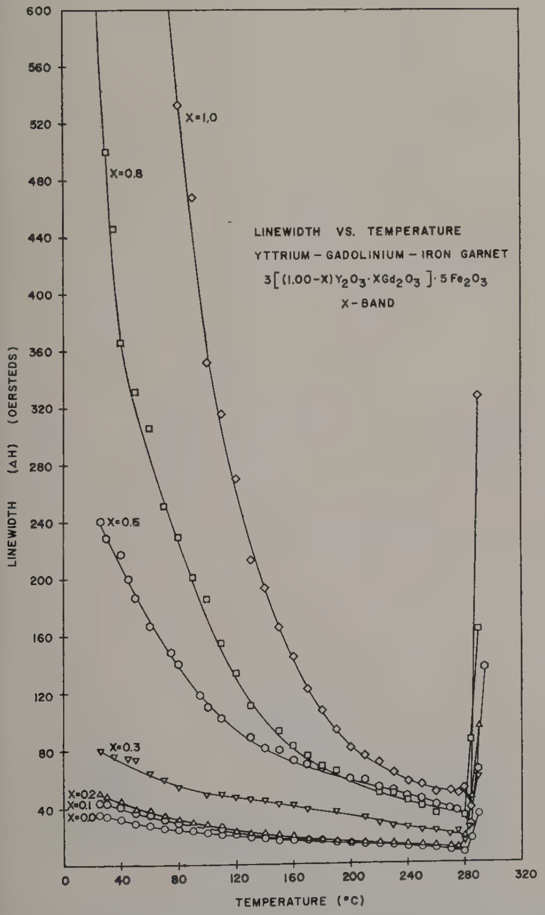


Figure 4 — Variation of linewidth with temperature for mixed yttrium-gadolinium-iron garnet.

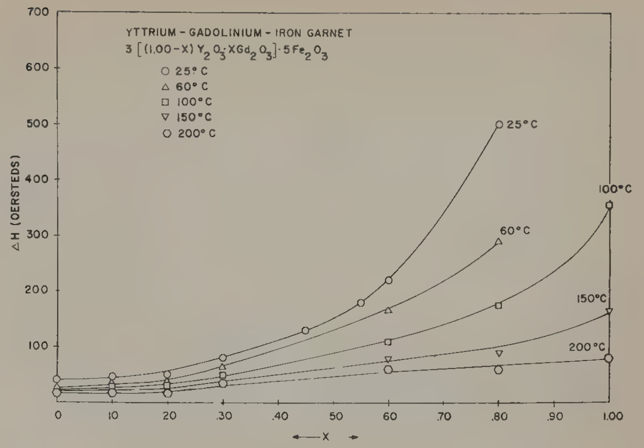


Figure 5 —Variation of linewidth with gadolinium content at various temperatures in mixed yttrium-gadolinium-iron garnets.

perature is observed, as expected, since the number of iron-iron interactions has not been altered. Variation of the magnetization with temperature in these materials is very interesting from an application standpoint. Particularly note the 60 per cent gadolinium substituted garnet. Here the magnetization of the material is constant over a fairly large temperature range. The magnetization can be varied at room temperature from the 1760 gauss of yttrium-iron garnet to around 100 gauss of gadolinium-iron garnet.

Figure 4 shows the linewidth variation as a function of temperature. Linewidths are observed to decrease in all cases as temperature is increased. At room temperature gadolinium-iron garnet has a very broad linewidth (greater than 2000 oersteds) as compared to that of yttrium-iron garnet (approximately 30 oersteds). Figure 5 shows linewidth variation with composition at various temperatures. At elevated temperatures the linewidth does not vary appreciably for all compositions. Figure 6 shows the g-factor variation of these materials with temperature. It should be noted that the g-factors for large gadolinium substitutions decrease as a function of increasing tempera-

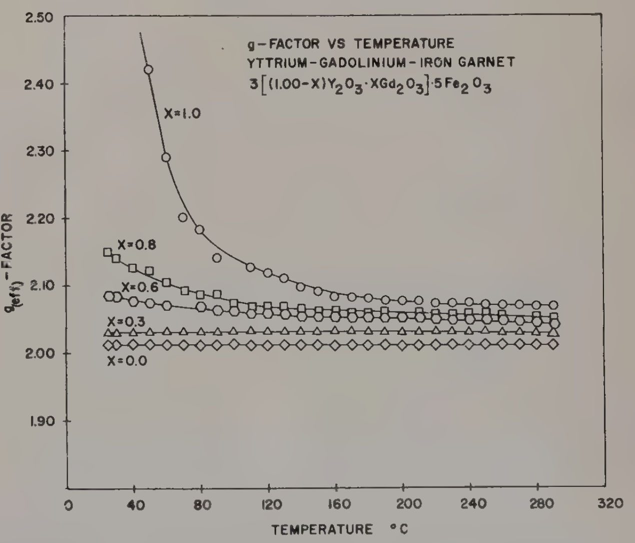


Figure 6 — Variation of effective g-factor with temperature for yttrium-gadolinium-iron garnet.

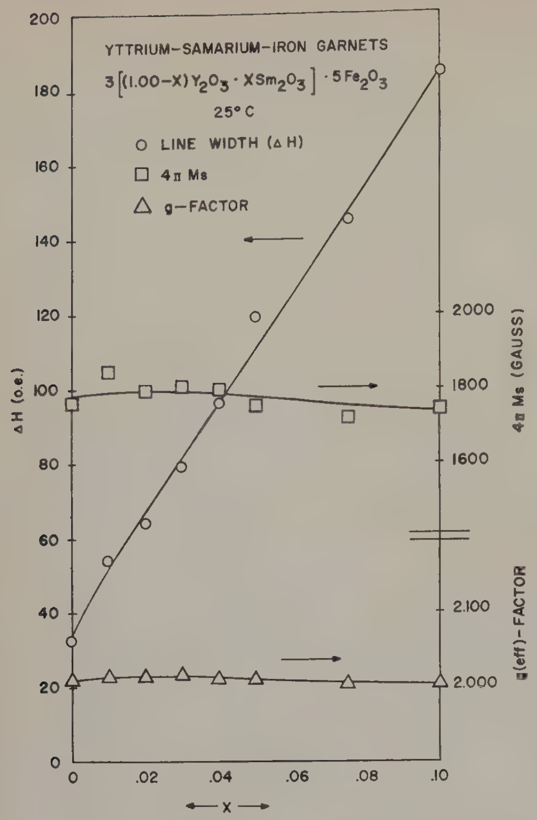


Figure 7 — Variation of linewidth, saturation magnetization and effective g-factor with samarium content in yttrium-samarium-iron garnet.

ture. The g-factor of yttrium-iron garnet does not vary with temperature. The g-factor of gadolinium-iron garnet at room temperature is quite large due to the compensation point of the magnetization.

Yttrium-gadolinium-iron garnets are quite useful in applications where medium magnetizations are desired with low to moderate linewidths. Also, in devices where some temperature compensation of the magnetization is desired. Some difficulty is encountered, however, in designing a device which operates over a fairly large temperature range when the operation of the device is quit dependent on linewidth.

Samarium surprisingly behaves very much like yttrium in the garnet structure. No compensation point has bee observed even though samarium has five unpaired electrons. The magnetization and Curie temperature o samarium-iron garnet are essentially the same as that fo yttrium-iron garnet. The odd behavior of the magnetization here evidently arises from the electronic configuratio of the samarium ion. The properties of yttrium-samarium-iron garnets have been studied in this work for substitutio up to 10 per cent samarium as shown in Figure 7 Linewidt is observed to increase in a linear fashion with increasin samarium additions. In the small substitutions studied

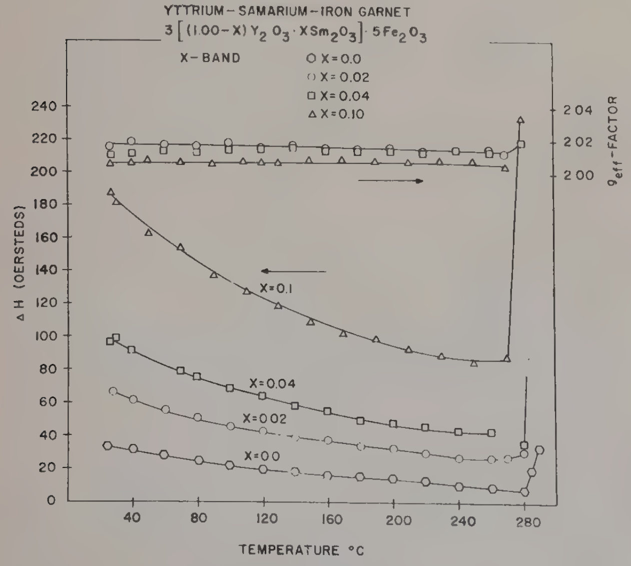


Figure 8 — Temperature variation of linewidth and effective g-factor for yttrium-samarium-iron garnet.

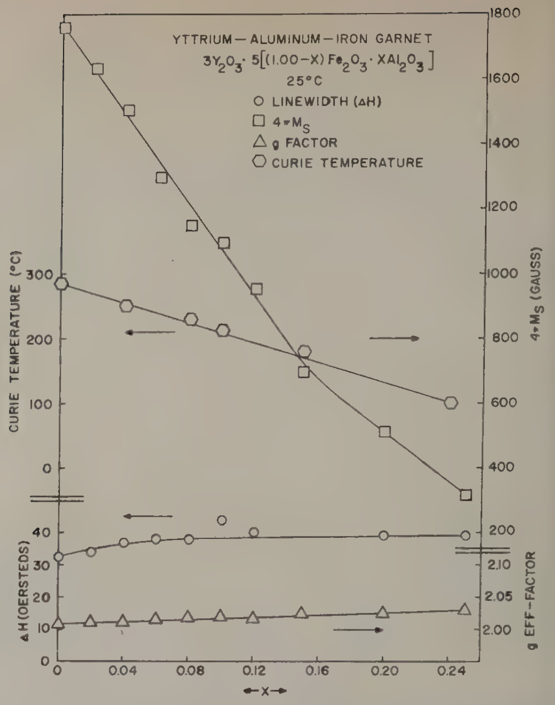


Figure 9 — Variation of linewidth, saturation magnetization effective g-factor, and Curie temperature with an aluminum content in yttrium-aluminum-iron garnet.

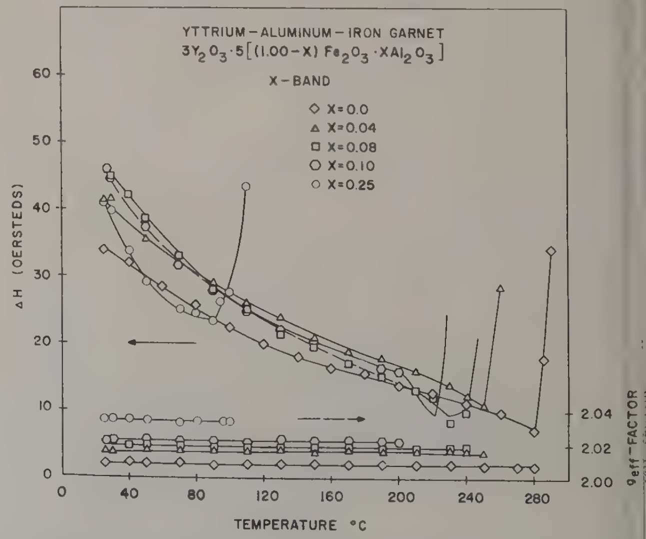


Figure 10 — Temperature variation of linewidth and effective g-factor for yttrium-aluminum-iron garnet.

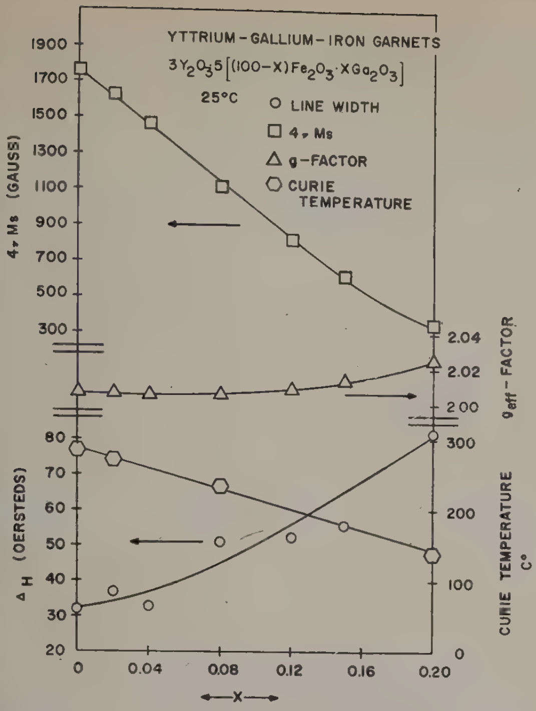


Figure 11 — Variation of linewidth, saturation magnetization, effective g-factor, and Curie temperature with gallium content in yttrium-gallium-iron garnet.

little change in the g-factor is observed. Little change in the magnetization is observed for all substitutions studied. The variation of linewidth and g-factor with temperature is shown in Figure 8. Linewidths decrease with increasing temperature as presented for the gadolinium substitutions. G-factors exhibit very little temperature dependence. All of the yttrium-samarium compositions have the same Curie temperature as expected since no change has been made in the number of iron-iron interactions in the structure.

These samarium substituted garnets exhibit the following properties: *constant magnetization for all substitutions; linear control of linewidth over very broad limits.* No temperature compensation in the material, as such, can be obtained.

Some interesting properties of substituted garnets can be obtained when trivalent transition metal ions are substituted for iron in the yttrium-iron garnet structure. The composition $3Y_2O_3 \cdot 5$ $[(1.00\text{-}x)\ Fe_2O_3 \cdot xAl_2O_3]$, has been investigated for $x=0$ to $x=0.25$ and the variations of saturation magnetization, linewidth, effective g-factor, and Curie temperature are shown in Figure 9. Trivalent aluminum goes into the structure primarily on the 24d site and has a zero magnetic moment. Therefore, partial substitution of aluminum for iron on the 24d site should reduce the magnetization as observed. Since the number of iron-iron interactions has been reduced, the Curie temperature is also expected to decrease as shown. Since no change has been made in the ions located on the 24c site, very little variation in linewidth is observed. No change in the g-factor was observed for the substitutions made. Figure 10 shows the variation in linewidth and g-factor as a function of temperature. Linewidth is observed to decrease with increasing temperature. Almost no change in the g-factor is observed. These materials are very useful in applications where a low linewidth and low magnetization are desirable.

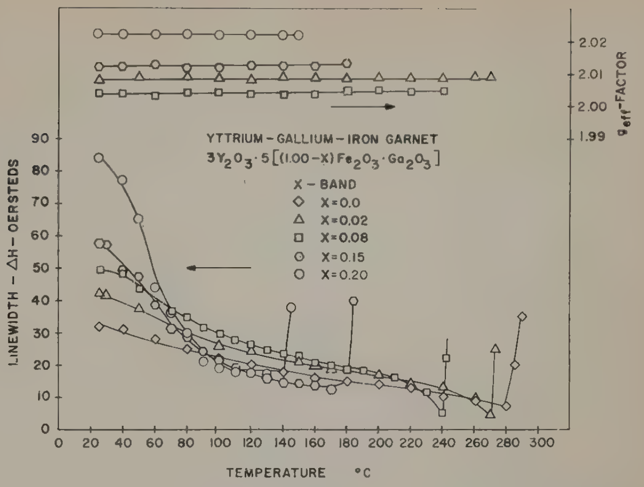


Figure 12 — Temperature variation of linewidth and g-factor for yttrium-gallium-iron garnet.

Yttrium-*gallium*-iron garnets, $3Y_2O_3 \cdot 5\ [(1.00-x)\ Fe_2O_3 \cdot Ga_2O_3]$, have been studied for $x=0$ to $x=0.20$ and the variation in the microwave properties is shown in Figure 11.

Gallium is very similar in structure to aluminum and predominantly locates also on the 24d site in the garnet structure so this substitution produces approximately the same effect on the microwave properties. Linewidths are observed to increase slightly as a function of gallium substitutions; $4\pi M_s$ decreases and g-factors remain almost constant. Curie temperatures are noted again to decrease. Figure 12 shows the variation of linewidth and g-factor with temperature. Linewidths decrease as a function of increasing temperature and g-factors are observed to remain constant. For a particular temperature these materials appear to be a little more active than the yttrium-aluminum-iron garnets. However, this advantage is overridden by the much greater cost of gallium as compared to that of aluminum.

Yttrium-*chromium*-iron garnets have been studied for very small additions of chromium as shown in Figure 13. Observations suggest that the electronic configuration of chromium is favorable for forming octahedral bonds; therefore, the ion locates on the 16a site even though it is smaller in size than iron.[8] Chromium ions have only three unpaired electrons compared to five for the iron it replaces, therefore, the magnetization of yttrium-chromium-iron garnets is expected to increase. Since the number of iron-iron interactions is reduced, the Curie temperature is again decreased as shown in Figure 13. Due to this decrease in Curie temperature, the magnetization as measured at room temperature appears to increase only slightly over the range of chromium added. It has been noted that only small substitutions of chromium can be made to the yttrium garnet structure;[8] the sharp change in linewidth for the highest chromium substitution attempted is attributed to this fact. Very little change in linewidth and g-factor is expected for chromium substitution as per previous arguments. Figure 14 shows the variation of linewidth and g-factor as a function of temperature in these yttrium-chromium-iron garnet compositions. Linewidths are observed again to decrease with increasing temperature and g-factors remain constant with temperature. At present these materials appear to have *almost no advantage* over the yttrium-aluminum or

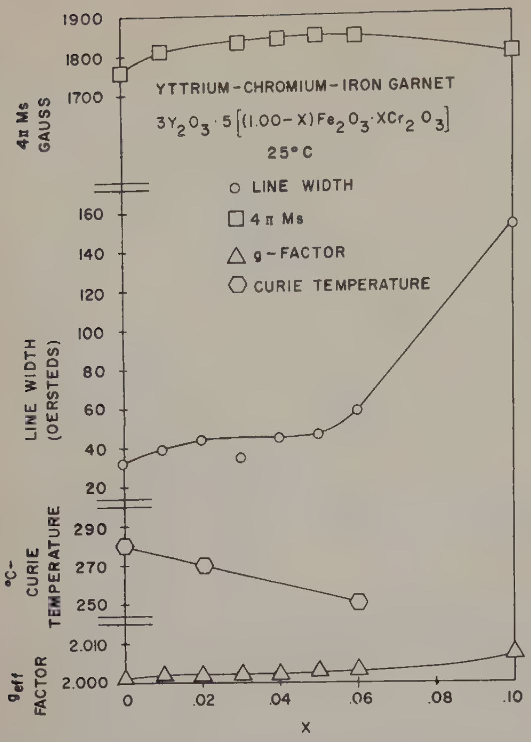


Figure 13 — Variation of linewidth, saturation magnetization, effective g-factor, and Curie temperature with chromium content in yttrium-chromium-iron garnet.

yttrium-gallium-iron garnets. It was thought in the beginning that these materials might be particularly useful in *limiter applications.* However, the data collected to date do not verify this assumption.

IV. High Power Considerations

At the present time magnetic materials are much in demand for use in high power applications. Some rare earth substitutions in yttrium-iron garnet increase very rapidly the high power thresholds of these materials. The ion located on the 24c site seems to control the point at which high power effects become evident. The high power thresholds are determined primarily by the linewidth of the material, the magnetization, and the spin wave linewidth. At X-band if the material is biased for resonance, the critical rf field strength at which nonlinear effects set in, according to Suhl[17] is $h_{crit} = \Delta H \sqrt{\frac{\Delta H_k}{4\pi M_s}}$ where ΔH is the observed linewidth, ΔH_k is the linewidth characteristic of the unstable spinwaves, and $4\pi M_s$ is the magnetization of the material. As illustrated in this work and others,[18,19] these properties can be controlled independently. Therefore, depending on the type of device desired it is possible to enhance or suppress high power effects. To enhance high power effects it is desirable to have ΔH and ΔH_k as small as possible and to have the magnetization of the material as large as possible. To suppress high power effects it is desirable to have ΔH and ΔH_k as large as possible consistent with a reasonable magnetization. Figure 15 shows the high power threshold of yttrium-iron garnet, yttrium-gadolinium-iron garnet, and yttrium-samarium-iron garnet. It should be noted that the thresholds increase as gadolinium or samarium are substituted for yttrium. The increase in the high power thresholds for gadolinium substitution in the structure is in part due to the reduction of the magnetization of the material. Linewidths are observed to increase also for these substitutions and small increases in ΔH_k have been measured. *Substitutions of samarium do not change the magnetization of the material but large increases in the line width have been observed and some increase in* ΔH_k *has been measured.* Therefore, for a better material for high power application some of the substituted garnets are more promising than yttrium-iron garnet. Other rare earth substituted yttrium garnets are still more inviting. Some of these are holium, erbium, and terbium substituted garnets.

At the present time metal ion substitutions in the garnet structure have proven to be the most useful technique for the control and variation of the properties of ferrimagnetic materials used for microwave applications.

Summary

The microwave properties (magnetization, linewidth, g-factor, Curie temperature) have been studied for a number of polycrystalline mixed garnets. The compositions investigated included solid solutions of yttrium-iron garnet with gadolinium-iron garnet, samarium-iron garnet, yttrium-aluminum garnet, yttrium-gallium garnet, and yttrium-chromium garnet. Ball mill mixing techniques were employed in the fabrication of all samples.

The results of the study of the microwave properties of these hybrid garnet compositions are believed to constitute useful information on all significant facets of the materials, including the important topics of high power effects and temperature stability. The merits of using these garnet compositions for microwave component applications are amplified by the fact that some of their properties may be independently controlled. In the case of yttrium-aluminum or yttrium-gallium mixed garnets only a very small variation in linewidth is observed while the magnetization $(4\pi M_s)$ of these compositions varies over a very large range. This

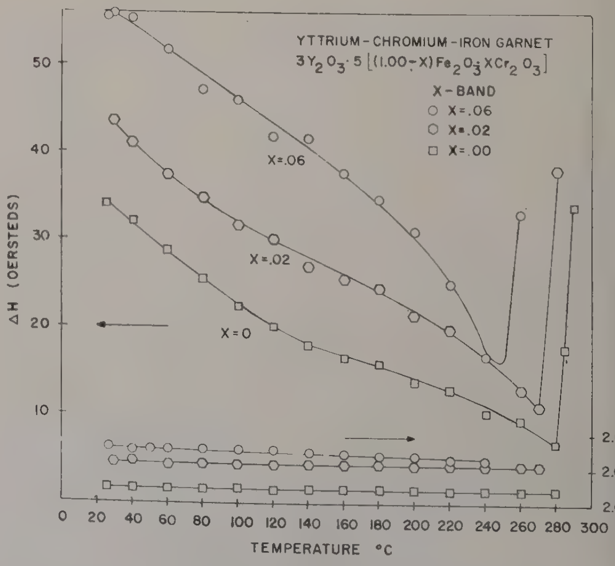
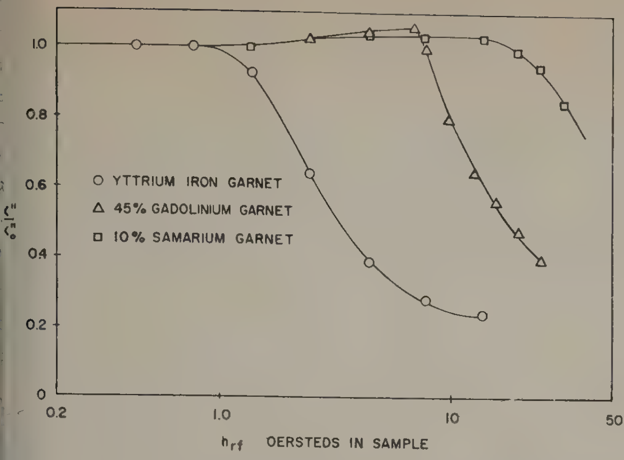


Figure 14 — Temperature variation of linewidth and g-factor for yttrium-chromium-iron garnet.



igure 15 — Variation of the magnetic susceptibility with microwave magnetic field for yttrium-iron, 55 per cent yttrium — 45 per cent gadolinium-iron, 90 per cent yttrium — 10 per cent samarium-iron garnet.

llows the stabilization of linewidth while varying mag-etization. In the yttrium-samarium garnet series, the agnetization is relatively constant while the linewidth aries over a large range depending on the samarium con-ent. In yttrium-gadolinium mixed garnet compositions, ne linewidth and magnetization both change with gadolinium content but the magnetization can be stabilized as a function of temperature. This allows for the easy fabrication of fixed field microwave components whose operation is optimized over a large temperature range.

Solid solution of yttrium-iron garnet with rare earth-iron garnets produces a material with a much superior high power handling capability. When suitable properties can be obtained from these hybrid compositions for the operation of a microwave component, the high power thresholds (above this level the operating characteristics of the component deteriorate) in the material will be much greater. The high power threshold of 10 per cent samarium- 90 per cent yttrium-iron garnet is twenty times that of yttrium-iron garnet.

"Molecular engineering" can be used not only to control the microwave properties, but also the high power thresholds and temperature stability of garnet materials for microwave applications.

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TEMPERATURE CONCEPTS IN MODERN RADIO

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Introduction

During recent years the term, temperature, has been used in a variety of new ways in the electronic engineering literatures. A few examples are the antenna temperature, the noise temperature, the electron temperature, the excitation temperature, and the spin temperature. The range of these temperatures is most striking. The antenna temperature may range from near zero Kelvin degrees to hundreds of millions of degrees. In some quantum electronic devices one even encounters a negative temperature. Furthermore, it often happens that quite different temperatures are associated with apparently the same object. For example, the system noise temperature of a solid state maser is 25°K, whereas the maser substance has a negative spin temperature of −2°K and has a body temperature equal to that of liquid helium bath or 4.2°K. As another example, a 30 Mc antenna looking up the sky has an antenna temperature of some 50,000°K while the temperature of antenna structure is only 290°K. To many radio engineers who consider the temperature only as a measure of the sensation of warmth or cold, these various temperatures may be confusing and sometimes amusing. The purpose of this paper is to examine the concepts of temperature appearing in the modern technical literature from the viewpoint of the electronic engineer. It will be shown how the different concepts of temperature are related to each other and to the classical concept of temperature.

The temperature concept was introduced into physics from classical thermodynamics. The science of thermodynamics deals with relations between heat and work, and is based on two general laws of nature, the first and second laws of thermodynamics. Temperature is one of the variables or coordinates for specifying the state of a thermodynamical system. Thus, the temperature of a body is its thermal state with regard to its ability for communicating heat to other bodies. The fundamental definition of an absolute temperature is the one originally proposed by Kelvin, and is based on the efficiency of a Carnot cycle.[1] If $\triangle Q_1$ and $\triangle Q_2$ are the quantities of heat flowing to a reversible heat engine operating on a Carnot cycle between two heat reservoirs at the respective temperatures T_1 and T_2, we have the relation

$$\frac{\triangle Q_1}{T_1} = \frac{\triangle Q_2}{T_2} = \triangle S \qquad (1)$$

where S is the entropy of the system. The numerica values for temperatures on this scale have been fixed by assigning 100 degrees as the interval between the ice point and the steam point.

In a classical thermodynamic sense, temperature is defined only for a system in thermal equilibrium, and it has a definite and unique meaning. Later when the kinetic theory of gases, quantum mechanics, and statistical mechanics were developed in physics, it was immediately realized that the concept of thermodynamic temperature also has significance in these areas. We now recognize a great variety of theoretical relations which exist between the physical state of a system and the absolute temperature under conditions of thermal equilibrium. The electromagnetic radiation from a black-body, the population distribution of atoms or molecules among various energy states, the mean square velocity of gas molecules, etc., are known to depend upon the absolute temperature. These theoretical relations may therefore serve equally well to define the absolute scale of temperature. For an ideal case under thermal equilibrium, all the definitions should give the same temperature.

In many physical processes, however, the system is not in thermal equilibrium. It is important to understand that a steady state condition does not imply thermal equilibrium. However, it has proved useful to extend the concept of thermodynamic temperature to non-equilibrium cases since temperature may still be a convenient parameter to describe the physical state of a system under consideration. Thus, many kinds of temperature have been defined by physicists. If the system is not in thermal equilibrium, different definitions of temperature will in general lead to different values for the same object under consideration. These temperatures must then be understood in terms of the principle or process used for the definition.

There are two major fields through which these new oncepts of temperature have been introduced from phyics to electrical engineering: they are radio astronomy nd quantum electronics. In spite of their short history, oth fields have made a tremendous progress and are today eceiving considerable attention. Radio astronomy is the cience of the universe as studied by radio techniques. A adio telescope, which consists of radio antenna and reeiver, is used to detect cosmic radio noise generated in nterstellar space and radio stars. The use of thermodyamic terminology in the measurement of these noise sigals and in the subsequent interpretation of the origins f the noise is common among radio astronomers. Quanum electronics is a branch of physical electronics which concerned with the quantum mechanical effects of lectrons in atomic or molecular system. Quantum eleconics include such subjects as ferrites, masers, laser, aser, etc. A knowledge of quantum mechanics and staistical mechanics is essential in understanding the priniples of these new devices.

In a broad way we may divide those concepts of temerature related to modern radio into three groups: (1) ose associated with Planck's law which describe the ature of the electromagnetic radiation from a black-body, 2) those associated with the statistical mechanics in hich the temperature is a parameter for describing a ertain type of distribution, and (3) those associated with he kinetic theory of gases in which the temperature is a easure of the average velocity of particles.

We shall first discuss the relations which are valid trictly under the conditions of thermal equilibrium and hen discuss their extension to non-equilibrium cases.

oncept of Noise Temperature

In most scientific measurements, we have an indicating nstrument which measures the quantity produced by a ignal source under consideration. If the sensitivity of he instrument is pushed higher and higher it is finally imited by spontaneous fluctuations. In electrical engieering the spontaneous fluctuations are simply called oise because of the acoustical effects accompanying the pontaneous electric fluctuations in radio receivers. No ignal can be detected if the signal-to-noise ratio drops elow a certain value. Thus the problem of noise is of ractical and serious concern to electrical engineers. The roblem becomes extremely important in the case of etecting very weak signals, such as in radio astronomy, pace communication, global communication, radar, etc.

The spontaneous fluctuations or noise in electric circuits nd systems may arise in many ways. Thermal noise, licker noise, shot noise, antenna noise are some examples.

Let us first consider the thermal noise from a resistor. The thermal noise in a resistor is caused by random moions of electrons in the resistor. The engineering signiicance is that a resistor acts as a noise generator. The mount of noise power available from a resistor can be alculated under conditions of thermal equilibrium using he law of thermodynamics. The available power P beween frequency f and f+df is given by Nyquist's theoem[2] and is a universal function of the absolute temperaure T of the resistor

$$P = hf \frac{1}{e^{\frac{hf}{kT}} - 1} df \qquad (2)$$

where h is Planck's constant $(=6.623 \times 10^{-34}$ joule-sec) and k is Boltzmann's constant $(=1.3803 \times 10^{-23}$ joule per deg. K). When $hf << kT$, which is valid at radio frequencies, this quantum expression reduces to a simpler form

$$P = kT\, df\,. \qquad (3)$$

This form is more familiar to radio engineers. The relation between the noise power and the absolute temperature given by Nyquist's theorem is only valid under thermal equilibrium conditions. However, it is very useful to extend this ideal case to cases under non-equilibrium conditions or even to various types of noise other than thermal noise. The available noise power per unit bandwidth of a one-port network not in thermal equilibrium, such as a noise generator, may be conveniently expressed by a noise temperature using Equation (3). Thus, the noise temperature of a one-port network at a specified frequency is the temperature of the resistor which has the same available noise power as the actual network.

The noise contribution of a two-port network or amplifier is conveniently characterized by an *effective input noise temperature.* If a two-port network connected to a noise-free input termination has an output noise power of N for a small frequency interval df, the network is said to have an effective input noise temperature of $T_e = \frac{N}{G\, k\, df}$, where G is the transducer gain of the two-port network. Thus, the effective input noise temperature is an "equivalent temperature" indicating the noise performance of the network or amplifier and does not refer to the physical temperature of the network or amplifier. For example, a parametric amplifier may have an effective input noise temperature of 180°K, whereas its physical temperature is near room temperature of 290°K.

Another import term, *noise figure* (or *noise factor*) is widely used by electronic engineers to describe the noise performance of a two-port network. The noise figure F of a two-port network is related to its effective input noise temperature by $T_e = 290\ (F-1)$. The concept and measurement of the noise figure have been carefully defined by IRE standards (see Proc. IRE, Vol. 45, pp. 983-1010; July, 1957 and Vol. 48, pp. 60-74; January, 1960). The concepts of effective input noise temperature has a distinctive advantage when the noise performance of a complete communication system (including antenna, transmission lines, etc.) is under consideration.

Concepts of Antenna Temperature and Sky Temperature

Most electronic engineers are familiar with the radiation resistance of an antenna. An antenna receives noise from all directions through its major lobe, side and back lobes, and the noise power is available to the receiver through the radiation resistance of the antenna. If the noise power available from an antenna in a small frequency interval df is P, then the *antenna temperature* or antenna noise temperature of radiation resistance, T_a, is defined by $T_a = \frac{P}{k\, df}$, according to Equation (3). Thus, the more the noise picked up by the antenna, the higher the antenna temperature. The antenna temperature is an equivalent noise temperature and is equal to the absolute temperature of a resistor which gives an available noise power equal to that of the antenna. It should be emphasized that the antenna temperature is not the temperature of the antenna structure.

The antenna temperature or the temperature of the radiation resistance thus defined gives no information about the origin or mechanism of the noise. However, it can be shown that when an antenna is placed inside a black-body enclosure the antenna temperature is equal to the absolute temperature of the enclosure.

A hot body, which is a perfect emitter-absorber of electromagnetic radiation, is known as "black-body." The intensity of radiation from a black-body at a frequency f(cps) under thermal equilibrium is given by Planck's radiation law[3]

$$B\,(f)\;df = \frac{2\,hf^3}{c^2}\;\frac{1}{e^{\frac{hf}{kT}}-1}\;df \qquad (4)$$

where T is the temperature of the black-body enclosure in degrees Kelvin, c is the velocity of light (3×10^8 m/sec), and B is the intensity or brightness of black-body radiation (watts/m^2/steradian/cps).

At radio frequencies where $hf << kT$, Equation (4) reduces to the well-known Rayleigh-Jeans approximation,

$$B\,(f)\;df = \frac{2\,kf^2\,T}{c^2}\;df\;. \qquad (5)$$

Equation (5) is especially important to radio astronomers as all the radio astronomical measurements are based on this relation.

Let us consider a black-body enclosure with a uniform temperature T. The enclosure is filled with radiation described by Planck's law. Every body immersed in this radiation naturally absorbs a certain amount of it, and at the same time must radiate on its own account. For thermal equilibrium the absorption and emission processes should balance. Let us place an antenna of radiation resistance R_a inside the enclosure. The radiation resistance, which is defined for an antenna in free space, is not altered due to the presence of the enclosure, since the black-body is a perfect emitter-absorber of electromagnetic waves. The antenna is terminated with a resistance equal to the radiation resistance for maximum power transfer. Under thermal equilibrium, the temperature of the black-body enclosure and the terminating resistor is identical (so is the temperature of the antenna structure in this situation). The power emitted and absorbed by the antenna must be balanced. The power emitted by the antenna is that available from the terminating resistor. From Nyquist's theorem the available power from the resistor is equal to kT df. Accordingly, one must conclude that the available noise power from the antenna due to the black-body radiation is also kT df, where T is the absolute temperature of the enclosure. Thus, the antenna temperature or the temperature of radiation resistance is equal to that of the black-body enclosure. This relation was first demonstrated by Burgess[4] and Slater.[5]

Through the law of thermodynamics and the theory of black-body radiation, we have demonstrated that when an antenna is placed inside a black-body enclosure, the antenna temperature is equal to the temperature of the black-body enclosure. However, noise due to the black-body radiation is only one of many types of noise which an antenna may pick up under ordinary situation. Moreover, the noise contribution to the antenna is a function of direction in the sky.

We shall now introduce the concept of *sky temperature.* If the intensity or brightness of noise from a small region of sky in the direction (θ, ϕ) at frequencies between f and f + df is equal to B (f, θ, ϕ), the *sky temperature* of that region is defined by the use of Rayleigh-Jeans formula as shown in Equation (5). The sky temperature is thus an "equivalent black-body temperature" of the sky and is equal to the temperature of the black-body occupying the same region of the sky and giving the same noise intensity as that actually measured by the antenna. The sky temperature thus defined gives no information as to the mechanism and source of noise radiation. In the case of non-thermal radiation, the sky temperature is in general quite different from the temperature of radio sources. The sky temperature consists o contribution from cosmic radio noise[6] and atmospheric absorption.[7]

The determination of the distribution of sky temperature in the celestial sphere is one of the important and fundamental researches in radio astronomy. Radio maps of the sky are made from the measurements of the sky brightness temperature. Radio maps covering from 64 M up to 1360 Mc covering large parts of the celestial sphere are now available.[6] These maps are not only useful fo radio astronomers to study the nature of the universe but also useful for radio engineers in estimating the sensitivity of the communication systems.

Finally, let us consider a most general situation where the antenna is pointing towards the sky with non-uniform sky brightness temperature distribution, T_s (θ, ϕ). Let D (θ, ϕ) represent the antenna directivity function (or gain function). The directivity function is defined as the ratio of the power U (θ, ϕ) radiated in a given direction (θ, ϕ) per unit solid angle to the average power U_a radiated per unit solid angle

$$D(\theta,\phi) = \frac{U(\theta,\phi)}{U_{av}}\;\frac{U(\theta,\phi)}{\frac{1}{4\pi}\displaystyle\iint_{4\pi} U(\theta,\phi)\,d\Omega}\;. \qquad (6$$

Thus,

$$\iint_{4\pi} D(\theta,\phi)\;d\Omega = 4\pi.$$

The directivity function D (θ, ϕ) represents a factor b which the power radiated by an antenna in a given direction (θ, ϕ) can be increased by using that antenna instead of an isotropic antenna. From the reciprocity theorem this also applies to receiving case. Thus, the noise received by an antenna from various directions must b weighted according to its directivity function. The antenna temperature then becomes a weighted average of th sky brightness temperature and is given by

$$T_a = \frac{1}{4\,\pi}\iint_{4\pi} T_s\,(\theta,\phi)\;D\,(\theta,\phi)\;d\Omega. \qquad (7$$

The integration must be carried over a full sphere. Fo earth-bound antennas, one half of the sphere will be th ground and the equivalent black-body temperature of the ground should then be used for that hemisphere.

Thus, the antenna may be considered as a device which couples through the radiation resistance the input terminals of the receiving system to an *equivalent* thermal reservoir which the antenna "sees" through its directional pattern. The absolute temperature of this thermal reservoir is equal to the antenna temperature T_a. The radiation resistance may be considered to be bathed in this reservoir and is in equilibrium with it.

In evaluating the sensitivity performance of a complete communication system, it is important to know the total effective noise of the system. Thus, the *total effective system noise temperature* T_{system} is a sum of the antenna temperature T_a and the receiver noise temperature T_R (including all passive R-F component losses such as cables, isolators, etc.). The thermodynamical approach to communication systems is very convenient and useful in the noise evaluation of the system.[8]

It is of interest to discuss some astrophysical temperatures[9] based on Planck's law. If the stars could be regarded as perfect black-body radiators, the temperatures can be determined from Equation (4) if B (f) can be directly measured. The temperature thus determined is called the *brightness temperature.* The measurement of B (f) requires the knowledge of the angular diameter of stars and, therefore, the brightness temperature can be derived for only those stars of known angular diameter. However, in the absence of the knowledge of the absolute value of B (f), one can still determine the temperature of stars by measuring the ratio of integrated brightness at two separated frequencies (f_1 and f_2) or wavelengths. From Equation (4) one can easily obtain by assuming $hf >> kT$, which is valid at optical frequencies,

$$r = \frac{B\ (f_1)}{B\ (f_2)} = \left(\frac{f_1}{f_2}\right)^3 e^{-\frac{h(f_1-f_2)}{kT}} \quad . \qquad (8)$$

From this ratio one can calculate the temperature which is known as *color temperature* of stars. It is also obvious from Equation (5) that radio frequency measurements can never yield color temperature since the ratio of the intensities at two radio frequencies is independent of the temperature.

The integration of Planck's law (see Equation (4)) with respect to frequency and to solid angle leads to the well-known Stefan-Boltzmann Law.

$$E = \sigma T^4 \qquad (9)$$

where E is the total rate of emission of radiant energy per unit surface area of a black-body in watts m^{-2} and $\sigma = 5.67 \times 10^{-8}$ watt m^{-2} deg^{-4}. The temperature thus defined is called the *effective temperature.* It is important to remember that these astrophysical temperatures (brightness, color, and effective) are derived on the assumption that stars emit according to Planck's law. Since stars do not radiate like a black-body and the stellar atmospheres are not in strict thermal equilibrium, these temperatures have in general quite different values for the same star.

Statistical Temperatures

Another useful extension of the concept of temperature is provided by statistical mechanics.[1] It is well known in statistical mechanics that the absolute temperature is a universal parameter needed for describing a certain type of distribution. Let N_i and N_j denote the number of atoms or molecules in the levels i and j with energies E_i and E_j. Boltzmann's distribution function states that under thermal equilibrium

$$\frac{N_i}{N_j} = \frac{g_i}{g_j}\, e^{-\frac{(E_i - E_j)}{kT}} \qquad (10)$$

where g_i and g_j are statistical weights of each energy level and T is the absolute temperature of the system. Equation (10) describes the population distribution of atoms or molecules among various energy levels as a function of the temperature. The lower energy level is more highly populated than the higher energy level. Boltzmann's distribution function plays important roles in atomic and molecular spectra of substances.

The radiation from a volume of gas is often characterized by its atomic or molecular spectra consisting of lines and bands. These spectra are caused by the change in the internal energy of the atoms or molecules. The intensity of these spectral lines and bands depend among other factors on the distribution of populations in the energy levels. Since the population distribution of atoms among various energy levels is determined by the temperature as shown in Equation (10), the variation of the line intensities in the spectra is also dependent on the temperature. It is thus possible to determine the temperature by studying the intensity distribution in spectral lines or bands. A number of temperatures can thus be derived using this method. When spectral lines due to transitions among excited electronic states are used for the temperature determination, it is called the *excitation temperature.* Thus, excitation temperature represents the distribution of atoms among excited levels. Similarly one can define *vibrational temperature* and *rotational temperature* by using measured relative intensities of vibrational and rotational bands in molecular spectra, respectively. Excitation temperature is widely used in astrophysics while vibrational and rotational temperatures are commonly used in the temperature measurements of hot flames and gases in industry.

In astrophysics one is interested not only in the relative numbers of atoms in various excited levels but also in the relative number of ionized atoms and neutral atoms. Under conditions of thermal equilibrium, the relative number of ionized and neutral atoms can be found from the Saha formula[9]

$$\frac{N_1 N_e}{N_o} = \frac{(2\,\pi\, m\, kT)^{3/2}}{h^3}\, \frac{2\, B_1\ (T)}{B_o\ (T)}\, e^{-\frac{X_o}{kT}} \qquad (11)$$

where N_1 and N_o are respectively the total number of ionized and neutral atoms, N_e is the electron density, B_1 (T) and B_o (T) are respectively the partition functions of the ionized and neutral atoms, and X_o is the ionization potential of the neutral atom. Equation (11) can be used in principle for the measurement of temperatures. The temperature thus defined is called the *ionization temperature.*

It should be pointed out that both Boltzmann's and Saha's formulae are based on a thermal equilibrium. If the system under consideration is in thermal equilibrium, these temperatures should agree with each other. However, in the case of a non-equilibrium system, the tem-

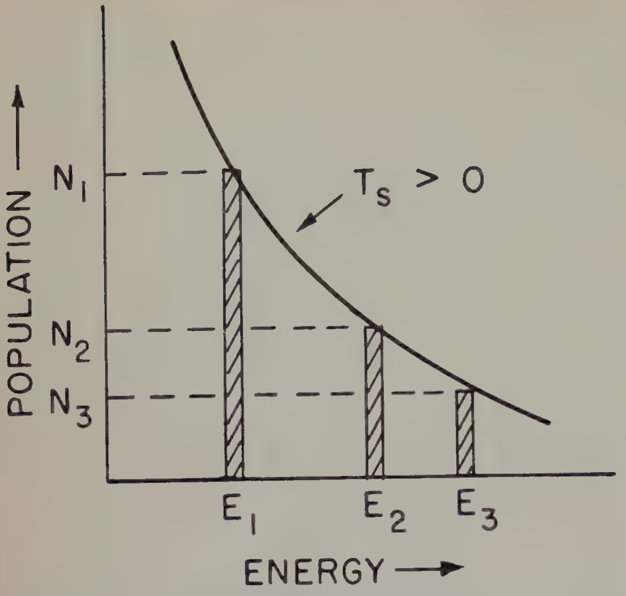

Figure 1 — Equilibrium population distribution atoms.

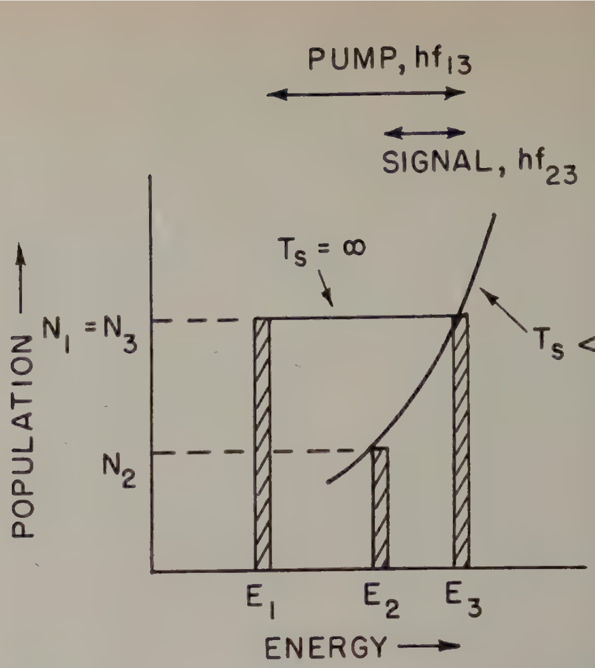

Figure 2 — Inverted population distribution and negative temperature.

perature becomes only a parameter in a representation of a certain type of distribution.

There are cases in which one has more than one system which may or may not be spatially separated. These subsystems may be very loosely coupled to each other and, therefore, are not necessarily in thermodynamic equilibrium to each other. However, the elements of a subsystem are in thermodynamic equilibrium by themselves inside the subsystem. For example, in a certain crystal, the vibrational system of the lattice and the spin system form two subsystems because the relaxation time for heat exchange between them, i.e., lattice-spin interaction, are often very long. When one can isolate spin systems thermally from the lattice, the *spin temperature,* which describes the population distribution among the various spin energy levels according to Boltzmann's distribution law, becomes a significant quantity. Under normal situations the lower energy level is more heavily populated than higher ones.

However, under suitable circumstances, the spin systems can be made such that the higher energy level is more heavily populated than the lower ones. This inverted population corresponds to a *negative temperature* in the Boltzmann's distribution function (see Equation (10)). The existence of negative temperature was first demonstrated by Pound and Purcell[10] using nuclear spin systems.

Another example for negative temperature can be found in solid-state masers. The word maser is an abbreviation of *m*icrowave *a*mplification by *s*timulated *e*mission of *r*adiation.[11] Let us consider a three-level solid-state maser,[12,13] in which there are three energy levels E_1, E_2, and E_3 with $E_1 < E_2 < E_3$ corresponding to the orientations of the magnetic moment of the electrons. Under thermal equilibrium conditions the number of atoms in each energy level is described by Boltzmann's distribution function. More atoms are thus found in lower energy levels than in upper ones as shown in Figure 1. In order to obtain an amplification, the population of atoms at energy levels E_1 and E_3 is equalized by the application of a strong radio frequency signal (called the pump) at a frequency $f_{13} = \frac{1}{h}(E_3 - E_1)$. The spin temperature for these two levels is then infinity.

However, the population distribution between the energy levels E_3 and E_2 is now inverted as shown in Figure 2. With this new inverted population distribution, a mild stimulation from a signal with a frequency $f_{23} = \frac{1}{h}(E_3 - E_2)$ will cause a net emission. The input signal is thus enhanced, and one obtains a signal amplification. The population inversion between levels E_3 and E_2 corresponds to a negative spin temperature for these two levels.

For more detailed discussions on the concept of negative temperature, the reader should refer to original papers.[10,14] It is interesting to add that the negative temperature is not below zero but above infinity. A system in a negative temperature will give up energy to another system at a positive temperature put into contact with it. Accordingly, a system at a negative temperature is not cold but is very "hot."

Kinetic Temperature

A further useful extension of the temperature concept is found in the kinetic theory of gases which provides a particle velocity interpretation of the concept of absolute temperature. The kinetic theory of an ideal gas[1] shows that under conditions of thermal equilibrium, the mean total translational kinetic energy $\overline{w}$ of the gas particles is

$$\overline{w} = \frac{1}{2} m \overline{v^2} = \frac{3}{2} kT \qquad (12)$$

where m is the mass of particle and $\overline{v^2}$ is the mean square velocity. Thus, the root mean square velocity of the gas particles is related to the temperature by

$$v_{rms} = \sqrt{\overline{v^2}} = \sqrt{\frac{3\,kT}{m}} \,. \qquad (13)$$

It is important to recognize the fact that the mean kinetic energy $\overline{w}$ depends only on the temperature and not on the pressure or volume, or kind of gas particles. The root mean square velocity of particles is dependent only on the temperature and the mass of the particles. The temperature defined by Equation (12) is referred as the *kinetic temperature* of the particles. For particles of more than a single kind, the same relation applies to each kind. Under thermal equilibrium at a temperature T, a heavy particle has a smaller root mean square velocity than does a lighter one. For example, at a temperature of 10,000°K the root mean square velocity of protons is 1.58×10^4 meters/sec, whereas that of electrons is 6.75×10^5 meters/sec.

However, for a system in non-thermal equilibrium, the kinetic temperature for a component particle is in general quite different from those of other component particles. Let us consider a plasma in an electric discharge tube. The electrons are accelerated by an applied electric field and have a high rms velocity. The kinetic temperature of the electrons or *electron temperature* is therefore very high. On the other hand, the rms velocity of the ions is small because of its heavy mass, and consequently the *ion temperature* is much lower than the electron temperature. An electron temperature of about 11,000°K is common in microwave noise tubes using gaseous discharge.

The kinetic temperature may be deduced from observations of spectral line broadening. Let us suppose that each individual atom at rest emits a sharp line of frequency f_o. If the atom is moving along the line of sight with a velocity v, the frequency of its emission will appear shifted due to the Doppler effect by an amount $\frac{v}{c} \cdot f_o$, where c is the velocity of light. Under thermal equilibrium the atoms are moving with a Maxwellian velocity distribution. The higher the temperature of the gas, the larger is the rms velocity of the atoms, and this results in a broader spectral line width. It can be shown[9] that the line width (full width between half intensity points) is

$$\triangle f = 2 \frac{f_o}{c} \sqrt{\frac{2\,kT}{m} \ln 2} \qquad (14)$$

where m is the mass of atom. It is important to remember that the spectral lines are also broadened by other causes, such as internal Stark effect, collision damping, radiation damping, etc. Therefore, when Doppler broadening is to be used for temperature measurement, a careful analysis must be made first to determine the magnitude of line broadening due to causes other than the Doppler effect.

Conclusion

In the preceding paragraphs the concepts of a large number of temperatures have been discussed. The basic physics involved in these concepts and measurements have been considered. For a system in thermodynamic equilibrium, these temperatures have the same value and the temperature has a definite and unique meaning. When the concepts of temperature are extended to systems not in thermodynamic equilibrium, the temperatures are in general quite different. Each temperature then becomes a convenient parameter for describing a certain physical state of the system. These temperatures must, therefore, be understood in terms of the principles by which they are defined.

With the rapid progress of new fields such radio astronomy, quantum electronics, space physics, etc., which have become closely connected with the electronic engineering, it is important that engineers keep up with the new concepts. A few years ago it was sufficient if an engineer knew how to use a thermometer. Now, however, he must distinguish between many kinds of temperature to which thermometers have no relation. We now have seen that the concepts of temperature are very much wider and deeper and that the understanding of these concepts are necessary to meet the problems in the modern electronic science and technology. This article is by no means a comprehensive treatment of the concepts of temperature, and the reader should refer to specialized papers and books[15,16] for more detailed information.

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LINEAR, COMPLEX-REFLECTION COEFFICIENT BRIDGE*

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Introduction

One basic handicap on the rapid growth of microwave technology is the lack of instrumentation which will allow the experimenter or design engineer to acquire a vast amount of information concerning microwave circuits in a very short time. The ready availability of information means that one is also acquiring a good deal of useless information, but since it comes so rapidly, this is no disadvantage. After all, it will be recognized that any information that does not describe the final design is useless information, except insofar as it reveals why another device or design was not used.

An analogous situation is that of mapping the surface of the earth. It is quite important to have a method of acquiring data very rapidly, such as aerial mapping. Such a photographic map yields tremendous amounts of information in a very short time and the precise characterization of the terrain can be made at a glance when a man looks at the picture. Unfortunately, much of the information gathering about microwave devices is analogous not to aerial surveying but to the tedious foot-by-foot measurement by surveying crews in that the time-consuming, point-by-point mapping of impedance functions with design change or with circuit parameters acquires this information in an exceedingly slow, though admittedly highly accurate fashion. Two fairly recent developments in instrumentation have tended to increase the rate at which information is gathered. One of these is the broad-band sweeping oscillator and the other is the broad-band reflectometer. Geared together, they allow one to make swept-frequency measurements of reflection amplitude coefficient in a nearly instantaneous fashion.

Unfortunately, as far as this writer is concerned, the amplitude of the reflection-coefficient is a poor substitute for the vector reflection-coefficient. And, indeed, except for routine production line testing, he is of the opinion that simple VSWR measurements are a snare and a delusion and too often mislead the microwave practitioner into trying to think in terms of a scalar field-quantity when he is actually dealing with a vector field.

In short and in this writer's humble opinion, the absolute necessity of any microwave laboratory is a complex-reflection-coefficient or complex-transmission-coefficient plotting device, which can be used not only at fixed frequencies but also in conjunction with a swept-frequency oscillator. Somehow or other the usual complex-reflection-coefficient measuring device with which the writer has been familiar was either cumbersome, intricate, or too slow to satisfy the need for a rapid survey instrument. Since he had also been involved in the design of some of these complex devices which involve single side-band modulators and so forth, it became readily apparent that what was needed was a simple, complex-reflection-coefficient plotter which had 100 per cent reliability for every day design measurements. It was, however, only after he had designed and operated the complex-reflection-coefficient bridge described in the following article that the extreme usefulness of the device was impressed upon him as strongly as it is now. The bridge is simple, stable, and essentially instantaneous in yielding information so that the effect of rapid modulation of circuit parameters is readily followed. Since no great effort was made for high accuracy, it has only a moderate accuracy. Its great virtue is not in measuring the characteristics of a final device, but in that it yields information about the device as it is being modified and subjected to changes. Thus, once a near optimum modification is obtained through the use of the complex-reflection coefficient plotter, the final de-

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* *Sponsored by Strand Labs., Inc., 294 Centre Street, Newton, Massachusetts.*

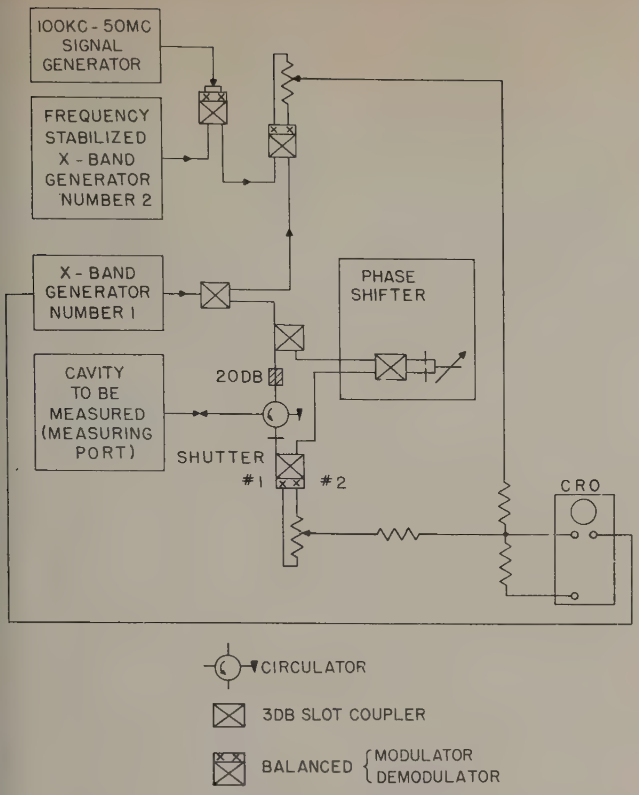

100KC - 50MC SIGNAL GENERATOR
FREQUENCY STABILIZED X - BAND GENERATOR NUMBER 2
X - BAND GENERATOR NUMBER 1
PHASE SHIFTER
CAVITY TO BE MEASURED (MEASURING PORT)
20DB
SHUTTER
#1
#2
CRO
CIRCULATOR
3DB SLOT COUPLER
BALANCED {MODULATOR DEMODULATOR

Figure 1 — Block diagram of Q-measuring bridge.

vice can be measured with any precision necessary by accepted precision techniques. All the impedance plots acquired by the device on an oscilloscope tube, before the final device is realized, have been lost, unless they are photographed on route, but they are not of any importance since they only point out the direction that the design had to take in order to realize the desired results.

In the sections that follow, the description of the device will be developed by describing how one may select a given component of the reflection-coefficient in a bridge arrangement. This technique will be utilized in order to describe the measurement of Q of a cavity as a particular example. In this case the Q measurement can be made with as much or greater precision as any other established technique. Most of the mathematical analysis of the signal processing is given in an appendix in order not to distract the reader who is only interested in the result. Finally, the application of this type of signal processing is discussed in terms of a total complex-reflection-coefficient plotter and in what seems to be a quite unrelated device, the linearized, electron-magnetic resonance bridge.

Theory of Bridge

A block diagram of a Q measuring bridge for X-band is shown in Figure 1. The bridge elements can be replaced by any other similar assembly of available equipment and are available in packaged form from Strand Labs. The frequency swept klystron signal, after it has been reflected from the cavity whose Q is to be measured, is combined with a signal derived from a reference arm that has its total length adjusted so that the dispersion in the reference arm matches the dispersion in the wave guide and circulator used in the cavity arm — that is, the electrical lengths are the same at all frequencies within the operating frequency band. The actual phase of the signal in the reference arm is controllable by a moving short circuit which acts as an attenuationless, variable phase-shifter so that the relative signal-reference phase is conveniently and rapidly adjusted.

The initial adjustment consists of removing the signal from the cavity or test piece arm by closing the attenuation in the signal arm, or substituting a matched termination at the measuring post. The output from the diode detectors is then balanced to zero by means of the variable potentiometer so that there is no signal from the bridge in the presence of the reference signal arm. Opening the signal arm attenuator prepares the bridge for operation. Since the signal arm contains an additional attenuation of 20 db over the reference arm, the crystal operating point remains essentially fixed at its balanced point.

Operation of Bridge

It is demonstrated in the appendix that the reference arm plays two roles. It provides a fixed signal which establishes the operating point of the detecting crystals in their linear region. It also provides a reference phase. The output signal is therefore proportional to the component of the signal voltage which is in phase with the reference arm voltage. Stated analytically this is expressed as follows

$$V_{out} = \alpha V_S \cos \phi$$

where V_{out} is the difference in the output of the two detecting crystals, α is a constant of proportionality depending upon the reference signal level and the diode characteristics, both of which are constants, and ϕ is the phase difference between the signal and reference voltages at one of the crystals. Thus, by adjusting the phase of the reference arm, one can examine either the real or imaginary part of the reflection-coefficient or any component of the reflection-coefficient that is of interest. In this notation, the complex-reflection-coefficient is indicated by Γ. The real component of the reflection-coefficient is the component of the complex reflection-coefficient on the resistive axis or the component in phase with the incident wave while the imaginary component of the reflection-coefficient is the component of the complex-reflection-coefficient on an axis perpendicular to the incident voltage wave.

The operating instructions are as follows. Klystron No. 1 is swept in time over a frequency range that includes the cavity resonance. Klystron No. 2 is stabilized to an internal reference cavity. The reference arm phase shifter is adjusted so that at resonance of the cavity to be measured the signal and reference are in phase, as indicated

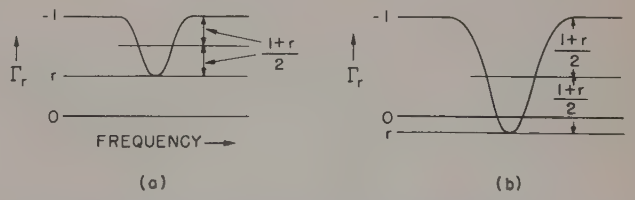


Figure 2 — Real part of cavity reflection-coefficient vs frequency for cavity. a) undercoupled, b) overcoupled.

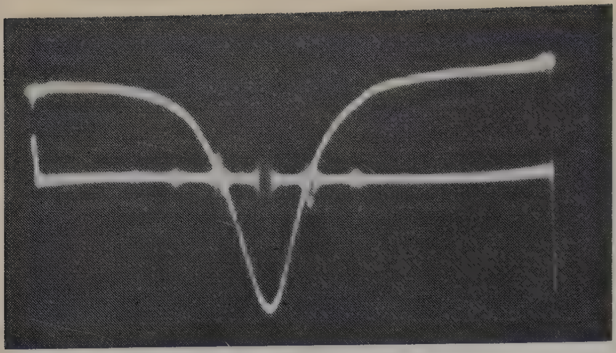


Figure 3 — Frequency markers set for measuring frequency width of the real part of reflection-coefficient.

in Figure 2. The reflection coefficient off-resonance is obviously equal to -1. If the cavity is undercoupled, r, the magnitude of Γ_r is also less than zero. For this reason the curve of Γ_r will not cross the base line in the case of an undercoupled cavity. For an overcoupled cavity, r will be greater than zero, and the Γ_r curve will actually cross the base line as indicated in Figure 2b. In either case, however, one proceeds to measure the frequency deviation required to change Γ_r by one-half of its total variation from off-resonance to resonance. The frequency-stabilized klystron No. 2 output is now amplitude-modulated by the rf signal generator, and the beat between klystron 1 and klystron 2 is obtained at crystal mixer A, the output of which is mixed with the bridge signal in a passive resistance network at the oscilloscope vertical axis terminal as indicated in Figure 1. Alternatively, these two signals can be displayed on separate beams of a dual-beam oscilloscope, or they may be shown separately on a single-beam oscilloscope if a mechanical or electronic switch is available. The frequency in the rf signal generator is set to a value near the half-width of the cavity resonance and the amplitude of the rf signal generator is increased until the first sidebands are seen by means of the beat note from the crystal mixer A. The frequency of the rf signal generator is now adjusted until these first modulation sidebands are at the half-excursion points of the Γ_r curve. This is indicated in Figure 3. The reading of the signal generator is noted, and the resonance reflection coefficient r is also noted at this measurement.

The reference arm phase shifter is now adjusted so that the reference angle at resonance of the cavity being measured is equal to $\pi/2$ radians. This condition is noted, for the case of cavities having a Q for which the cavity resonance can be covered within the repeller sweep of the klystron, by obtaining a symmetrical Γ_i curve. Again, in this case, the signal generator is adjusted in frequency so that beat sidebands between klystron No. 1 and 2 correspond to the maximum and minimum of the Γ_i curve, with the carrier beat note occurring at the zero of Γ_i. This situation is shown in Figures 4 and 5. Again the setting of the rf signal generator is noted; and this number, together with the value of r determined from the Γ_r curve, can be used to obtain an independent value of the cavity unloaded Q, Q_o.

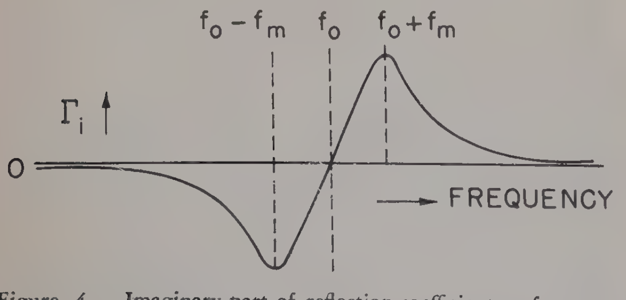


Figure 4 — Imaginary part of reflection-coefficient vs frequency for cavity Q_o measurement.

The pertinent equation from the appendix is applicable to reduce both observations:

$$Q_o = \frac{f_o}{(1-r)\ f_m}$$

where Q_o is the cavity unloaded Q, f_m is the rf signal generator frequency, and f_o is the cavity microwave resonance frequency. Note that the *sign* of r is important being *negative* for undercoupled cavities and *positive* for an overcoupled cavity, as explained above.

Some of the advantages of this type of measurement are that one is not required to have monographs or tables in order to convert the data to a value of the cavity unloaded Q. Second, the output is linear over a large range of signals so that it is not necessary to measure the crystal detection law — or to determine a receiver output law if an i.f. superheterodyne system is used. It also appears that for low Q's the phase shift method involved in the Γ_i measurements is a more reliable way of determining the cavity Q because one is not required to have a signal generator with a constant amplitude over the bandwidth of the cavity. Errors that may arise in the phase shift determination due to a differing dispersion in the cavity and reference arm can be removed merely by shorting the cavity terminals and adjusting the phase of the bridge with the cavity of the circuit. Then the cavity is unshorted and the maximum or minimum of the Γ_i curve may be examined near a point where the bridge phase was adjusted. The correction for the slight dispersion unbalance and source signal amplitude variation will thus contribute a negligible error if the bridge is operated in a region near a point where the reference arm phase has been adjusted with a short on the cavity terminals. In any case, an accuracy of 5 per cent for the measurement of Q's of 100 or greater appears to be easily achievable.

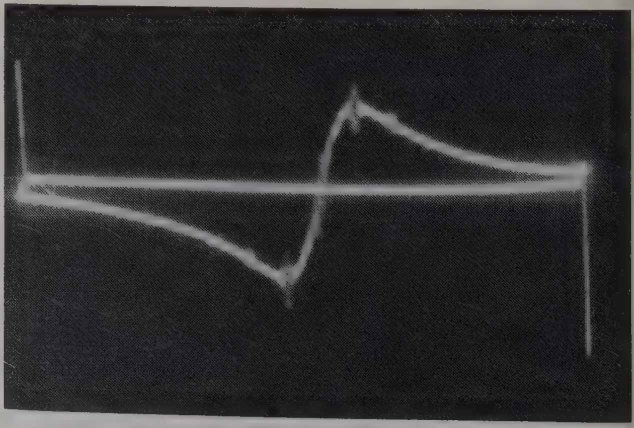


Figure 5 — Frequency markers set for measuring width of imaginary part of reflection-coefficient.

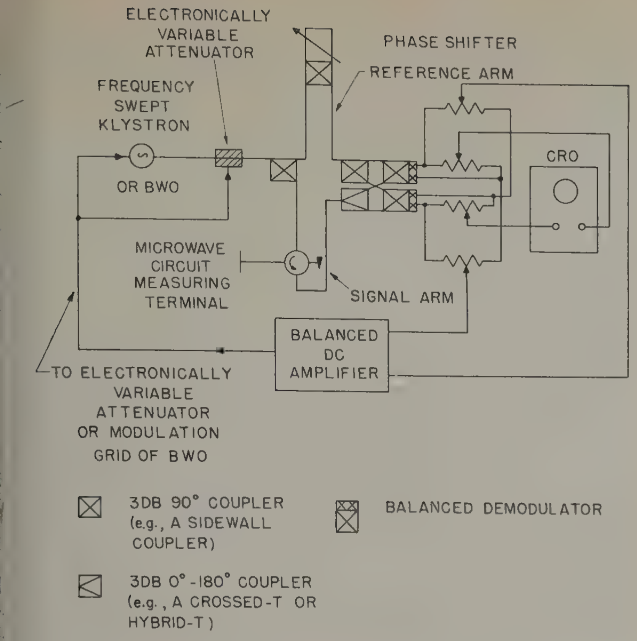

ELECTRONICALLY VARIABLE ATTENUATOR
PHASE SHIFTER
REFERENCE ARM
FREQUENCY SWEPT KLYSTRON
OR BWO
CRO
MICROWAVE CIRCUIT MEASURING TERMINAL
SIGNAL ARM
BALANCED DC AMPLIFIER
TO ELECTRONICALLY VARIABLE ATTENUATOR OR MODULATION GRID OF BWO
3DB 90° COUPLER (e.g., A SIDEWALL COUPLER)
BALANCED DEMODULATOR
3DB 0°-180° COUPLER (e.g., A CROSSED-T OR HYBRID-T)

Figure 6 — Block diagram of complex-reflection-coefficient bridge.

High-speed Reflection Coefficient Plotter

Complex-reflection-coefficient plotters using balanced modulators have been available in the past. The simplicity of the intrinsically-balanced, reflection-coefficient bridge constructed by the principle described above has much to recommend it. A block diagram of an intrinsically balanced coefficient bridge is shown in Figure 6. It will be seen that the reference arm signal is now split, through the use of a 3 db reactive coupler, so that two reference signals, one 90° phase-lagging the other, are available. The circuit measuring arm signal is also split in a 3 db divider which yields zero or 180° phase shift, such as a crossed-guide T, or septated waveguide power divider. The two orthogonal reference arm signals are now combined with the two measuring arm signals in two 3 db, 90° couplers and the resultant signals are detected in two balanced crystal pairs. The balanced output of one crystal pair will thus be a projection of the reflection-coefficient to be measured on a given reflection-coefficient axis. The second crystal pair will have an output (by virtue of the 90° phase shift introduced in the reference signal by the 3 db, 90° coupler that was used to produce the two reference signals) which is a projection of the measurement arm reflection coefficient on an axis perpendicular to that used by the first pair of crystals.

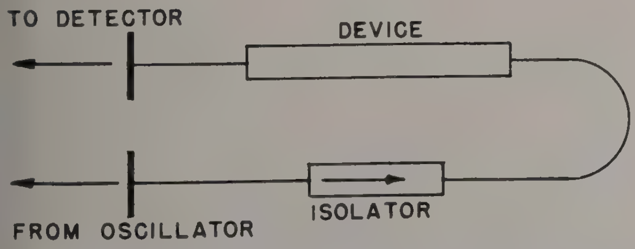
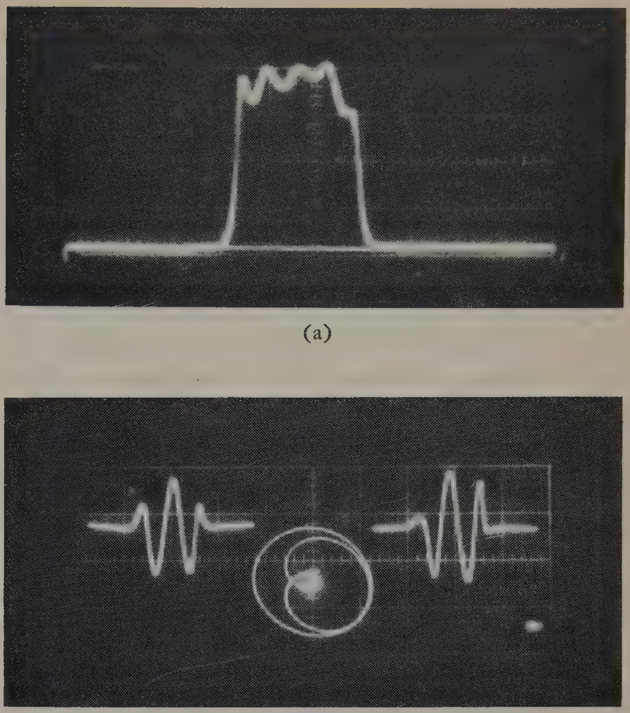


Figure 7 — Transmission Loop for measuring complex transmission coefficient.


(a)

(b)

Figure 8 — (a) Band-pass filter power transmission curve with linear frequency sweep. The band-pass in centered at 9300 mc and is 43 mc wide. (b) Real and imaginary parts of complex transmission coefficient — (right and left), and (center) polar plot of complex transmission coefficient of band-pass filter used in 8a.

If these two signals are applied to the horizontal and vertical deflection amplifiers of a cathode ray oscilloscope, and the over-all signal gain equalized in the two amplifiers, the cathode ray tube will plot the complex-reflection-coefficient with some arbitrary normalization. The reference axes to which the measuring circuit reflection coefficient is referred may be rotated on the presentation cathode ray tube by using an attenuationless phase-shifter in the reference arm of the bridge.

A constant normalization of the complex-reflection-coefficient plot obtained on the cathode ray tube may be achieved by using the summed output of the crystal pairs to operate a leveler — for example, a ferrite attenuator for klystrons or the modulation grid of a backward wave oscillator source — to maintain constant signal detection sensitivity in the bridge. Both arrangements are indicated in Figure 6. It will be apparent that the response time of this direct-coupled, balanced, reflection-coefficient plotter is limited only by the bandpass of the cathode ray oscilloscope deflection amplifiers. For this reason, this type of reflection-coefficient plotter is especially applicable in situations requiring fast plotting time although it can be used for any plotting time application — for example, for use in which the data is not indicated on a cathode ray tube but on a X-Y chart recorder. In this case the chart recorder inputs replace the horizontal and vertical deflection inputs in the cathode ray oscilloscope application.

As we indicated at the beginning, the most important feature of the complex-reflection-coefficient plotter is the fact that it can acquire masses of data very rapidly. We give two examples of the acquisition of such data.

The reflection-coefficient plotter is being used in the laboratory to investigate the properties of multiply tuned resonant circuits both in transmission and reflection. It is readily visualized that in order to use the plotter for transmission measurements the signal arm circulator is replaced by a transmission loop as indicated in Figure 7. The changes that are made by minor tuning of any of the elements of the circuit are readily followed in terms of the transmission or reflection-coefficient plot.

As an example we show some data taken with the unit used as a complex transmission plotter. The device being investigated is a direct-coupled, resonant-cavity, band-pass filter. A simple *power* transmission curve is shown in Figure 8a. In Figure 8b we show in a composite photograph of oscilloscope tracings the real and imaginary parts of the *complex* transmission coefficient in the left and right hand corners. The combination of the two signals to give a polar plot of the complex transmission coefficient is indicated in the center of the figure.

It will be noted that the transmission phase changes by 5π over the bandpass. Unless frequency or timing pips are put on the complex transmission plot we have no way of determining how linear this phase shift is. This would be a simple and convenient addition to the instrumentation. Note however that if the frequency sweep is linear in time (as is the case here) then for a linear phase shift with frequency the real and imaginary parts of the transmission coefficient should vary sinusoidally with time. Inspection of the plots indicates that the components of the transmission coefficient do, indeed, vary sinusoidally with time and so we conclude that the phase shift is linear with frequency to within probably a few per cent, the accuracy of this measurement.

Probably of more current interest is the use of the reflection-coefficient plotter to measure semi-conductor diode or varactor characteristics. In this case, the match at a fixed operating bias point may be studied as a function of frequency. Here the effect of modification of tuning plungers and tuning screws is readily and rapidly followed in order to achieve an optimum over-the band-match. We will discuss, however, another aspect of varactor measurements, that is, their operation at a fixed frequency under variable bias conditions. For example, in Figure 9 we show a complex-reflection-coefficient plot from two gallium arsenide varactors of commercial make. Both of these diodes indicate a reasonable reactive variation in impedance with bias voltage. It will be realized that the figure of merit of a varactor is measured by how close to unity reflection-coefficient it can come when the bias is varied from the match-point bias. It is readily evident that one of these diodes is better than the other. It should be pointed out that in solving the problem of obtaining optimum operating conditions several variables must be adjusted: these are the dc bias, the magnitude of the ac variation of potential, and the input impedance match. The adjustments required to achieve the best circles for a given varactor takes only a few seconds. The application of an ac potential along with a dc potential allows one to sweep over the total varactor characteristic to plot it out, while the impedance matching elements are tuned. The most time consuming part of taking this data was that involved in waiting the prescribed one minute for development of the picture, the device having been adjusted in a few seconds. With these data in mind, several other types of diodes were also observed with varying bias potential. Here again, the match-point is readily achieved so that a maximum variation in diode characteristics can be realized with a given amount of bias variation. It is interesting to note that one expects varactors, if they are mainly a reactance varying device, to follow circles like those on Smith chart describing a change in reactance. With diodes, if one expects to observe a change in resistance, then one would expect to follow the more nearly straight lines which indicate changes in resistance.

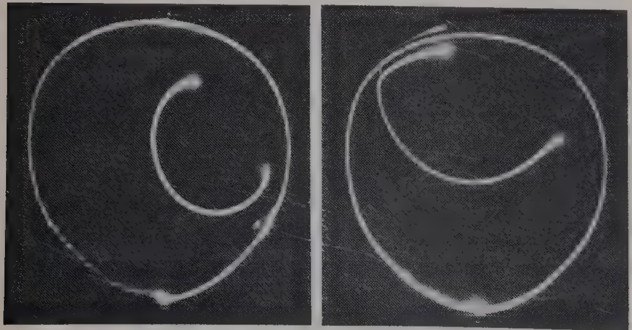


Figure 9 — Complex reflection-coefficient plot of GaAs varactors as bias is varied. Outer circle is a plot of r = 1.

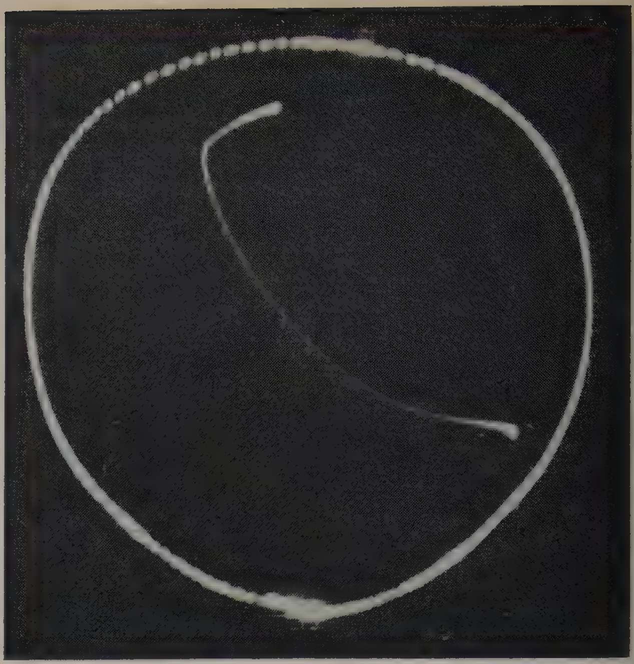
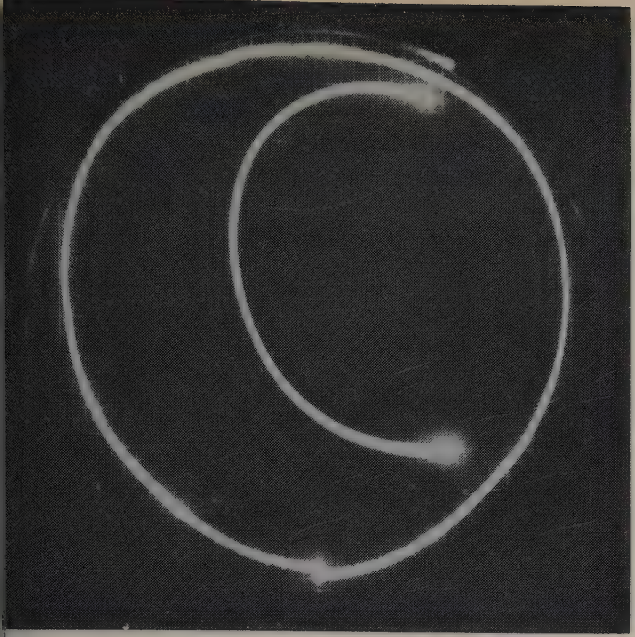


Figure 10 — Complex-reflection-coefficient plot of 1N23B diode with varying bias.

It soon became evident that some microwave diodes are not pure variable resistors and, indeed, there are types which can be selected which have varactor properties equal to the best obtainable. As an example, we indicate in Figure 10 a typical variation of a 1N23B microwave crystal with varying bias potential. It is seen that the impedance changes crudely along the lines of change in resistance. However, in Figure 11 we indicate another commercial diode which has almost pure reactive variation with potential and which has a cut-off frequency in excess of 100 kmc. It is interesting to note it is a matter of a few seconds to check a diode to see whether it has promising varactor properties or not since the impedance matching and reactance variation plot is so easily ob-



igure 11 — Silicon diode with varactor properties. Complex-reflection-coefficient with varying bias. Compare with Figures 9 and 10.

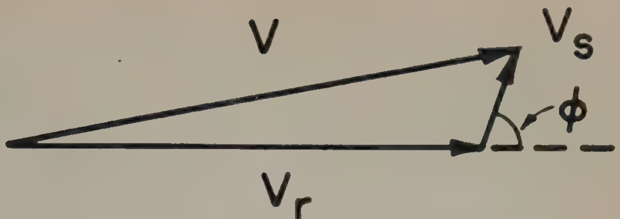


Figure 12 — Vector addition diagram.

ained. By using this impedance plotting chart, the vriter has been able to comb through exceedingly inexensive commercial diodes and obtain a good yield of high erformance silicon varactor diodes with cutoff frequenies in excess of 100 kmc. Thus, this piece of microwave lumbing becomes a modern instrument of transmutation, niraculously converting an inexpensive diode into an exeedingly high priced varactor.

requency Stabilization

It will be apparent to anyone who has had experience n the field of klystron frequency stabilization that the urve representing the imaginary part of the reflectionoefficient of a cavity, as shown in Figure 4 or Figure 5, as the characteristics that promise to make such a bridge good discriminator for an automatic frequency stabilizaion loop. In fact, it is just this curve, the imaginary part f the sample cavity reflection-coefficient that is used to tabilize the signal klystron to the cavity in the Strand abs Model 600 Electron Magnetic Resonance apparatus. similar arrangement is used in an inherently balanced iscriminator in the several Strand Labs stabilized klytron supplies, such as the Model 300. The importance of he voltage linearity, of course, is that though the power o the sample cavity may vary by a factor of N, the stabiliation loop gain varies only as $N^{1/2}$, instead of N^1 as in he conventional modulation, or unbridged, reflection-cofficient stabilization schemes.

It may be pointed out that the complex-reflectionoefficient plotter also forms the heart of an electron magetic resonance bridge with a high sensitivity. If the hase of the reference arm of the reflection-coefficient lotter is adjusted so that one output gives the real part f the reflection-coefficient of a cavity (containing the agnetic resonance sample attached to the measuring oint) then the other detector output will give a signal vhich is proportional to the imaginary part of the reflecion-coefficient. Thus, one output of the reflection-coefficient bridge may be used to stabilize a klystron to the cavity frequency by using the discriminator-like curve provided by the imaginary part of the reflection-coefficient. The changes in the real part of the reflection-coefficient are then linearily detected in the other pair of crystals, and any changes in this reflection-coefficient due to sample absorption appear at this output. The advantage of this type of operation in detecting changes in the real part of the reflection-coefficient is due to the linearizing effect of the reference signal on the detection crystals. Since the output voltage (or current) of the crystals is proportional to the cavity arm voltage, the variation in sensitivity is only proportional to the sample cavity power. Without the reference signal biasing the crystal detectors, this would not be so since the detection efficiency of the diodes also varies with the power. In a conventional bridge without the reference signal the sensitivity thus would decrease as the square of the power. Another way of justifying the enhanced sensitivity is to realize this scheme is essentially a superheterodyne receiver with a zero frequency i.f., or, in the case of magnetic resonance apparatus which has a time modulated reflection-coefficient, the i.f. frequency is the frequency of this modulating field — in the case of the Strand Labs 602 EMR this is 6 kilocycles.

The somewhat different form of electron magnetic resonance measurement may also be obtained with this apparatus. In electron magnetic resonance measurements, the real part of the paramagnetic susceptibility changes the cavity resonant frequency, and the imaginary part of the paramagnetic susceptibility changes the cavity loss or Q_L. It is apparent then that if the signal klystron is ex-

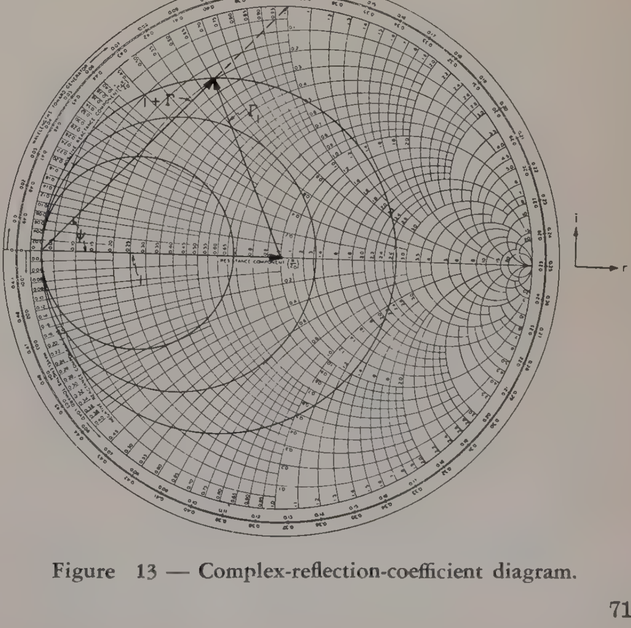


Figure 13 — Complex-reflection-coefficient diagram.

ternally stabilized to a frequency corresponding to the sample cavity resonance frequency, in the absence of paramagnetic resonance, and if the bridge reference phase is set to yield the real and imaginary parts of the cavity reflection-coefficient, then one of the outputs of the bridge will be proportional to the change in cavity frequency or to the real part of the magnetic susceptibility while the other output of the bridge will be proportional to the change in cavity loss or the imaginary part of the magnetic susceptibility. If both of these outputs are monitored (with separate amplifiers and indicators) as the magnetic field which is applied to the sample cavity is varied through the value which brings the paramagnetic sample into resonance with the klystron frequency, both real and imaginary parts of the susceptibility may be observed simultaneously!

Appendix

If the phase between the signal and the reference arm is taken as ϕ, then the magnitude of the voltage, which is the vector sum of the signal and reference voltages as seen in crystal No. 1, Figure 1, is

$$V=(V_r^2+V_s^2+2V_rV_s\cos\phi)^{1/2}\,. \qquad (1)$$

Equation (1) expresses the cosine law as applied to the vector addition problem indicated in Figure 12. Since V_s^2 is 1/100th of V_r^2, Equation (1) for the voltage at crystal No. 1 may be written as

$$V_1=V_r\left(1+\frac{V_s^2}{2V_r^2}+\frac{V_s}{V_r}\cos\phi\right)\,. \qquad (2)$$

Because of the 90° phase shift characteristic of an inductively coupled 3 db coupler, the phase difference between these two signals at crystal No. 2 is $\pi+\phi$, and this means that by a similar argument the resultant voltage seen by crystal No. 2 is

$$V_2=V_r\left(1+\frac{V_s^2}{2V_r^2}-\frac{V_s}{V_r}\cos\phi\right)\,. \qquad (3)$$

If either of these signals is detected in a crystal having a dc output voltage which is some general function of the rf voltage — as, for example

$$V_{dc}=f(V_{rf}), \qquad (4)$$

the change in the dc voltage due to the change in the peak rf voltage may then be written as a Taylor series expansion of $f(V)$:

$$V=V_o+v,\ v<<V_o$$

$$V_{DC}=f(V_o)+\left.\frac{\partial f}{\partial V}\right|_{V_o}v+\frac{1}{2}\left.\frac{\partial^2 f}{\partial V^2}\right|_{V_o}v^2+\ldots \qquad (5)$$

For functions $f(V)$ that one can expect to find, the first derivative exists, and the product of this derivative with a small voltage change is the dominant term.

On this basis the output from crystals No. 1 and No. 2 may be written as

$$V_{1,\,2}=f(V_r)\pm\left.\frac{\partial f}{\partial V}\right|_{V_r}\left(V_s\cos\phi\pm\frac{V_s^2}{2V_r}\right) \qquad (6)$$

with the high-order terms suppressed as being unimportant because of the large ratio of V_r to V_s. If the two crystal outputs are initially balanced, the difference between the two crystal outputs with the small signal will be linear in V_s and is

$$V_{out}=V_s\cos\phi\left(\left.\frac{\partial f_1}{\partial V}\right|_{V_{r1}}+\left.\frac{\partial f_2}{\partial V}\right|_{V_{r2}}\right)\,. \qquad (7)$$

If the reference arm signal is kept essentially constant in amplitude, the derivative terms will be constant, and so we can simplify Equation (7) by writing it in terms of a constant α:

$$V_{out}=\alpha V_s\cos\phi\,. \qquad (8)$$

In the common notation, if V_s is measured by the magnitude of the reflection coefficient, r, then the angle ϕ is the phase angle of the reflection coefficient θ *with respect to some reference angle.* If V_{si} is the input signal voltage to the cavity arm then we can write

$$\Gamma=re^{i\theta}=r\cos\theta+ir\sin\theta$$

$$r=-\frac{V_s}{V_{si}} \qquad (9)$$

For example, if the angle ϕ is adjusted by means of a phase shifter in the reference arm to be equal to zero at cavity resonance, then ϕ is equal to θ, the phase angle of the complex-reflection-coefficient. Furthermore, $V_s\cos\phi$ is the real part of Γ except for the normalizing factor in the denominator, V_{si}. Since the output presentation is relative we can make a one-to-one correlation between V_{out} from the linear bridge with the real part of the reflection-coefficient, with this setting of reference arm phase.

On the other hand, if the angle ϕ is adjusted to be $\pi/2$ radians at resonance, then $\theta=\phi-(\pi/2)$, and the output signal is proportional to $V_s\sin\theta$. This, as may be seen from Equation (9), is simply the imaginary part of the reflection-coefficient, Γ, within an identical normalization factor, V_{si}^{-1}. In Figure 13 we show a Smith chart with typical cavity Q circles. It will be seen that measurements of the maximum of $\Gamma\sin\theta$ and $\Gamma\cos\theta$ suffice to orient these Q circles and hence should be sufficient to define the cavity unloaded Q and coupling Q. It is apparent that, as the frequency changes and one traverses the boundary of these Q circle, the maximum and minimum values of the imaginary part of Γ, $\Gamma\sin\theta$ are at the same points that the real part of Γ, $\Gamma\cos\theta$ differs from its resonance value by an amount equal to the radius of the Q circle $(1+r)/2$. The real part of Γ has a total variation measured by $\alpha V_s(1+r)$, as indicated in Figure 2. Thus, the half voltage point of this curve corresponds to the magnitude of the radius of the Q circle, $(1+r)/2$ and also to the maximum and minimum points of the imaginary part of Γ, as shown on the curve in Figure 4.

We can express these curves analytically by noting that the complex-reflection-coefficient is[1]

$$\Gamma=\frac{\beta-1-j2Q_o\delta}{\beta+1+j2Q_o\delta} \qquad (10)$$

where β is the coupling coefficient, Q_o/Q_{ext}; Q_o is the cavity unloaded Q; and δ is the fractional frequency deviation from resonance, $\delta=(f-f_o)/f$. The real and imaginary parts of Γ are readily determined from this equation to be

$$\Gamma_r=\Gamma\cos\theta=\frac{(\beta^2-1)-(2Q_o\delta)^2}{(\beta+1)^2+(2Q_o\delta)^2} \qquad (11)$$

$$\Gamma=\Gamma\sin\theta=\frac{4Q_o\delta\beta}{(\beta+1)^2+(2Q_o\delta)^2}$$

We can now solve for the maximum and minimum of Γ_i by differentiating Γ_i with respect to δ and setting the derivative equal to zero. The frequency deviation for maximum or minimum Γ_i is then found to be

$$\delta=\frac{\beta+1}{2Q_o} \text{ for } \Gamma_i \text{ a maximum or a minimum.} \qquad (12)$$

From Equation (10) we see that when δ equals zero, Γ is real and has a value equal to $(\beta-1)/(\beta+1)$ which we shall call r. In terms of r, Equation (12) is written as

$$Q_o=[(1-r)\ \delta]^{-1} \qquad (13)$$

If we write δ in terms of a deviation from resonance f_m as

$$\delta=\frac{f_m}{f_o} \qquad (14)$$

where, since f_m is small compared with the resonance frequency we can replace f in the denominator by f_o. This means that we can write the unloaded Q in terms of the deviation frequency from the resonance frequency and resonance reflection coefficient as

$$Q_o=\frac{f_o}{(1-r)\ f_m} \qquad (15)$$

We can also investigate the properties of Γ_r. In particular, we can solve for the frequency deviation for which the real part of the reflection-coefficient is changed from its resonance value to a value half-way between its off-resonance value, -1, and its resonance value r — the point for which $\Gamma_r=-(1+r)/2$ — and we obtain an expression analogous to Equation (12). Now however, Q_o is given in terms of Γ_r as follows:

$$\delta=\frac{\beta+1}{2Q_o} \text{ when } \Gamma_r=-(1+r)/2 \qquad (16)$$

Using the arguments implied after Equation (12) we can express the unloaded Q in the cavity in the terms given in Equation (16) as follows:

$$Q_o=\frac{f_o}{(1-r)\ f_m} \qquad (17)$$

These results can be demonstrated graphically by a construction on the Smith chart of Figure 13. It is relatively easy to show that the angle, ψ, the angle that the vector $1+\Gamma$ makes with the real Γ axis is such that the following relationship holds:[2]

$$\tan\psi=2Q_o\,\frac{\delta}{\beta+1}$$

It can be seen from Figure 13 that the locus of points for the maximum or minimum value of Γ_i is such that the value of ψ at this point is equal to 45°, and hence its tangent is equal to 1. We thus obtain the relationship given in Equation (12). It is also apparent from the graph that at the maximum and minimum value points of Γ_i that the real part of $(\Gamma+1)$ is equal to one-half of its total variation; in other words, it is equal to the radius of the Q circle. This observation leads us then directly to the expression given before in Equation (16).

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CENTRIFUGAL FORMING OF PARABOLOIDAL ANTENNAS

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FRANKLIN W. BARR
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HRB-SINGER, INC.
State College • Pennsylvania

Introduction

Consider a liquid in a cylindrical container of radius R rotating with angular velocity ω about the vertical Z axis as shown in cross section in Figure 1. The forces acting on a surface particle of coordinates ρ and z are the centrifugal force $m\omega^2\rho$ in the radial direction and its weight mg downward, balanced by a buoyant force B. It is seen that the slope of the surface at this point is

$$\tan\theta = \frac{dz}{d\rho} = \frac{m\omega^2\rho}{mg} \qquad (1)$$

from which

$$z = \frac{\omega^2}{2g}\,\rho^2\ . \qquad (2)$$

Thus, it is evident that the free surface of a liquid rotating with uniform angular velocity about a vertical axis will stabilize in the form of a paraboloid of revolution about this axis.

This principle has been known since Newton's laws were first applied to derive the basic mathematical theories of hydrodynamics. In 1901 a U.S. patent was granted to one Albert Krank of Warkaus, Grand Duchy of Finland, Imperial Russia, for a method to capture the liquid paraboloid in solid form. In 1908 the late great American Physicist, R. W. Wood,[1] successfully employed a rotating dish of mercury as the collecting mirror in an astronomical telescope. These early developments apparently were not pursued further at that time. Possibly the principle could not be reduced to practice since materials available at that time did not include the synthetic resins produced by modern plastics technology. A material which has a definite freezing point is not satisfactory for centrifugal forming of paraboloids, as the surface loses the desired contour when the material is partially solidified. It is necessary to use a material which solidifies by a continuous increase in viscosity throughout the entire body of liquid. Perhaps a large market for paraboloidal microwave antennas was required to stimulate additional work on what was then regarded as merely a scientific curiosity.

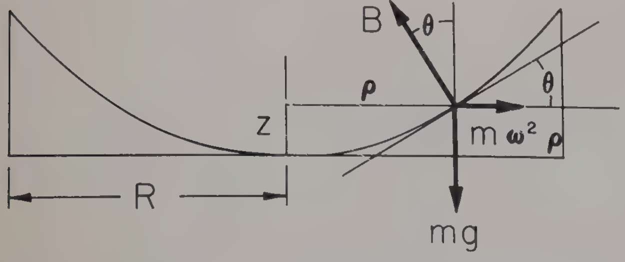

Figure 1 — Liquid in container rotating about vertical axis.

Recent Developments

The first known application of this principle to the fabrication of microwave antennas was at the Aeronautical Electronic and Electrical Laboratory, U.S. Naval Air Development Center, Johnsville, Pennsylvania, beginning in 1952. A series of experiments were carried out in which epoxy, phenolic and polyester resins of various types were hardened in rotating containers on a 78 rpm turntable. Paraboloids thus formed were used as experimental X band antennas, with excellent results.

In 1956, HRB-Singer learned of this development and constructed a special adjustable-speed turntable. Mirrors of searchlight reflector optical quality were produced[2] by combining the earlier replica mirror techniques of Hass and Erbe[3] with centrifugal forming. (For precision optics the two-step replica mirror process of Hass, Erbe, and Bradford[4] modified by Saxton and Kline[5] is superior and is the basis for the current HRB-Singer replica mirror product line.) While centrifugal forming is relatively simple, it is time-consuming and limits the variety of materials which can be used to fabricate antennas. Rather than form each antenna centrifugally, it is preferable to use the centrifugal forming technique only to make molds from which antennas can be made by conventional methods.

Mold Making Techniques

To make a concave paraboloid, a quantity of a resin such as Rezolin phenolic toolplastik is catalyzed to cure at room temperature and poured into a container on the turntable, where it is rotated at constant speed until it hardens. To make a convex paraboloid, the surface of the concave paraboloid is coated with paste wax or silicone grease to prevent adhesion and more phenolic resin is poured in it. When this second casting hardens, the two can be used as matched male and female dies to make antennas by laminating or other conventional techniques. Molds up to 4 feet in diameter have been made by this technique. Note the concave mold shown in Figure 2. To conserve phenolic resin at the edges of this mold, the plywood and sheet metal container in which it was poured on the turntable was provided with a false bottom.

Dish Fabrication Techniques

Centrifugally formed molds can be used to fabricate paraboloidal dishes by stamping, sheet metal spinning, vacuum drawing, laminating and other techniques. However, to exploit fully the precision of these molds, steps must be taken to ensure that the front surface of the dish is a faithful replica of the convex mold surface.

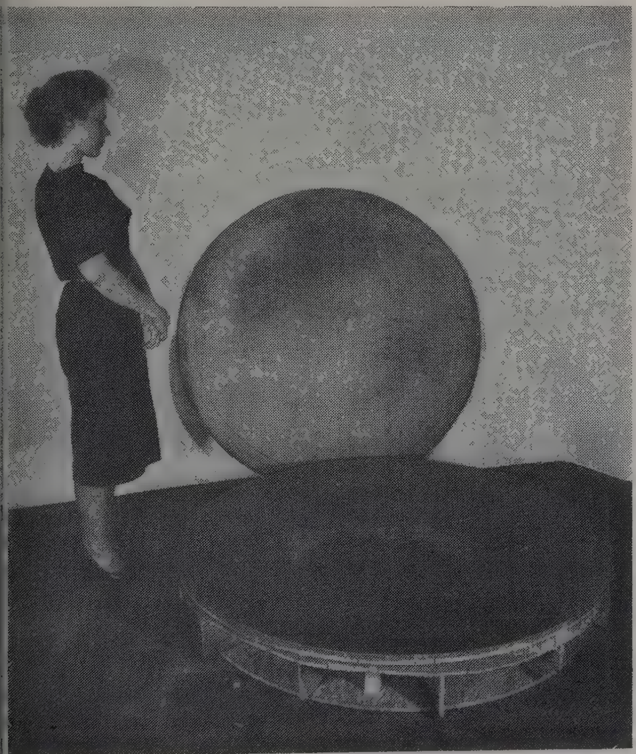

Figure 2 — Paraboloidal dies of four-foot diameter.

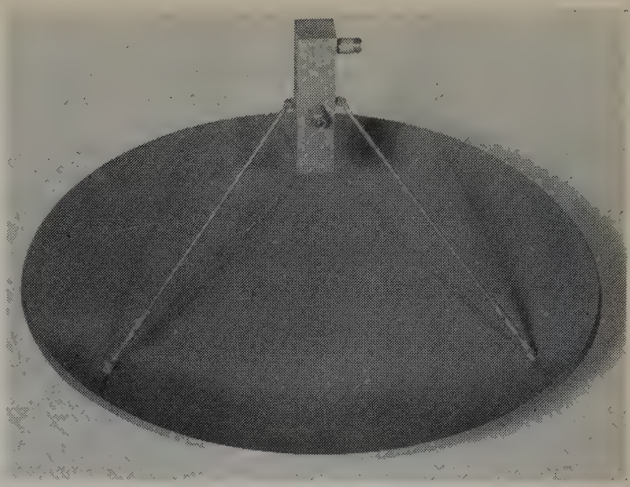

Figure 3 — Two-foot diameter reflector with bi-polarized feed.

One technique used involves electrodeposition of a copper coating on the surface of the convex mold. This surface is first polished with wax to prevent adhesion, then coated with graphite or some other non-adhering conductive material. A copper layer a few thousandths of an inch thick is electroplated on the surface and the mold is removed from the bath, rinsed, and dried. A laminate of resin-impregnated glass fibers is then laid up on the electroplated copper. The surface of the concave mold is waxed and polished, then the convex mold with the loose laminate is pressed into the concave mold to squeeze out excess resin. The resin is cured with the laminate clamped securely between the concave and convex paraboloidal molds. The copper skin separates from the convex mold surface and adheres to the laminate when it is removed from the mold. The result is a copper-surfaced dish with a rugged laminated backing.

In a second variation of this technique, a flame-sprayed metal layer might be deposited on the convex mold, then a laminate built up and pressed into the concave mold as before.

In a technique which is preferred because it requires no special equipment such as an electroplating bath or molten metal spray gun, a wire mesh is bonded to the front surface of the dish. Wire fabric such as that commonly used for window screens is stretched over the waxed convex mold and a laminate is laid up over it as in the above methods. The wire mesh must of course be fine enough to be indistinguishable from a continuous metal surface at the frequency for which the dish is intended.

Antenna Performance

Paraboloidal dishes made by the above techniques have performed very well as microwave antennas. Figure 3 shows a 2-foot diameter reflector with a LeVine-Sichak bi-polarized feed.[6] The directional pattern it produces is shown in Figure 4. Similarly Figure 5 shows the pattern for such a feed in conjunction with a 4-foot diameter reflector. These excellent results are obtained by matching precise reflectors with feeds that are capable of equivalent precision.

Conclusion

The centrifugal forming technique produces paraboloids

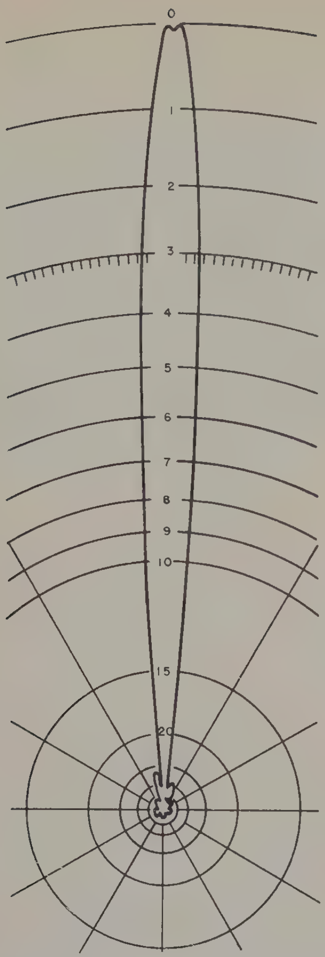

Figure 4 — Directional power pattern of two-foot diameter reflector with bi-polarized feed. 5550 Mc; side lobes down 25 db.

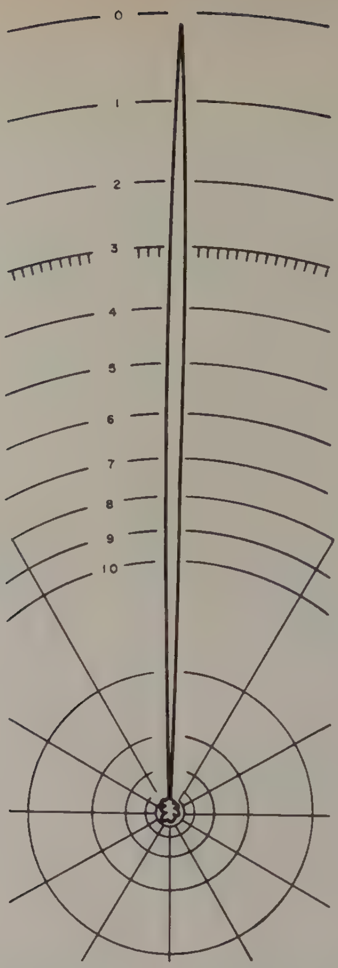

Figure 5 — Directional power pattern of four-foot diamete reflector with bi-polarized feed, 9600 Mc; side lobes dow 35 db.

of better quality than those attainable by conventional pattern-making methods. Furthermore, the cost of centrifugally formed paraboloidal tools is less, since no tedious carving and template fitting is involved. Centrifugal forming of molds permits large scale manufacture of antennas for K band and higher frequencies by slight modification in conventional laminating techniques, and should mak possible the reduction to practice of some principles thu far considered only in theory or achieved experimentall only under carefully-controlled laboratory conditions.

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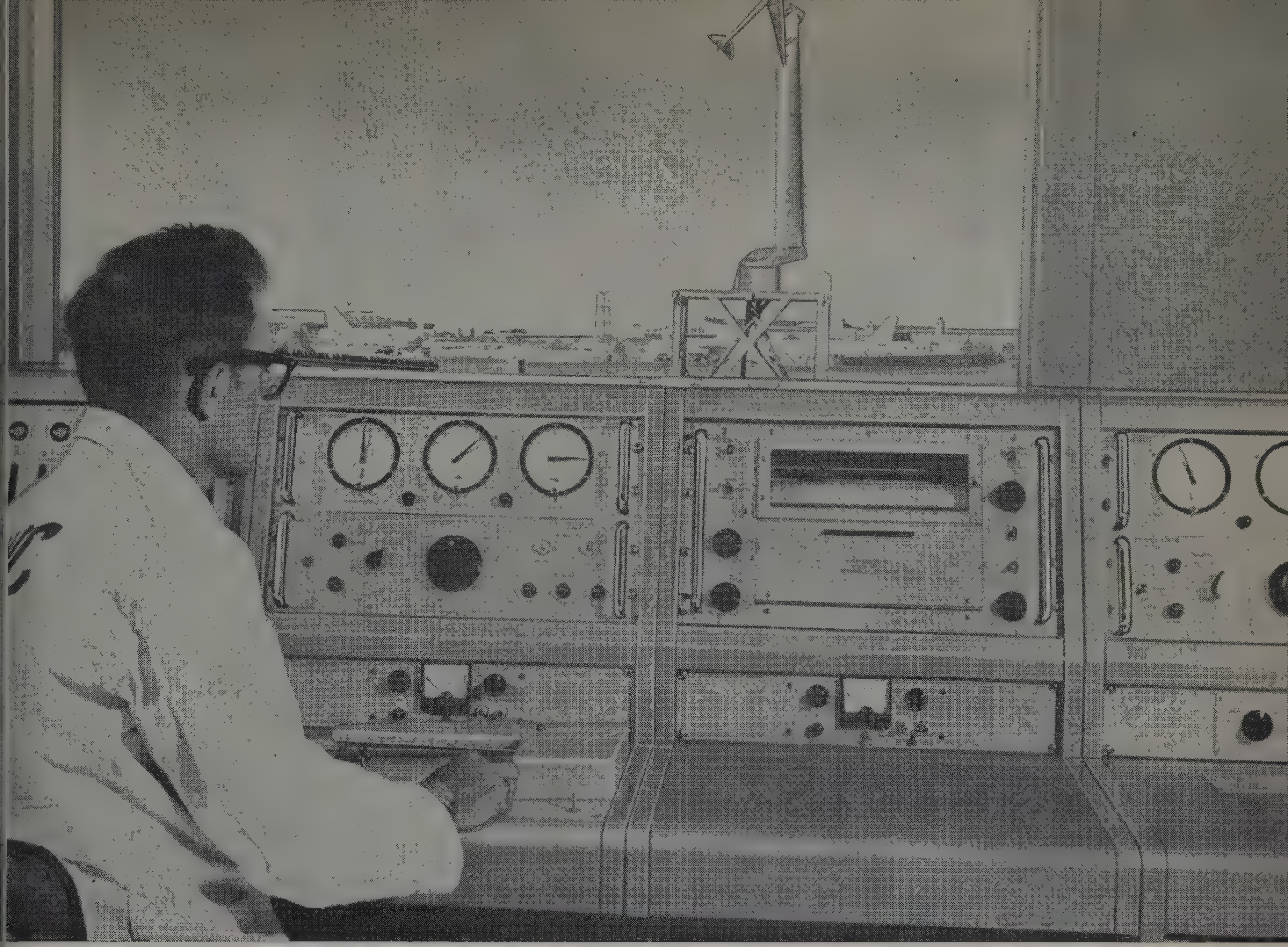

Scientific-Atlanta antenna pattern recording console at Boeing Airplane Company, Wichita, Kansas, with Scientific-Atlanta model range tower in background.

Advancing the Art of Aircraft Antennas

Boeing uses versatile Scientific-Atlanta equipment to design and evaluate antennas for B-52H bombers

A Boeing B-52H global bomber packs more total firepower than that expended by all the Allied and Axis bombers in World War II. Each B-52H will carry four Skybolt missiles plus a potent assortment of other weapons. Equipped with penetration aids, including electronic countermeasures (ECM) and decoys, the B-52H can strike as many as five military targets on a single mission. It is produced for the Air Force's Strategic Air Command at the Wichita, Kansas, Division of Boeing.

Obviously, the design of antennas for such an aircraft demanded nothing short of "state of the art." As it turned out, Boeing engineers *advanced* the state of the art in the design of ECM antennas for B-52Hs and B-47s. They were aided significantly by a new antenna test facility, consisting predominately of Scientific-Atlanta equipment—including pattern recorders, wide range receivers, signal sources, and a model range tower.

The foremost advantage of Scientific-Atlanta instrumentation is *versatility*. Complete frequency coverage is provided with recordings proportional to voltage, power, or db in either rectangular or polar coordinates. Owing to the equipment's wide frequency coverage, sensitivity, and flexibility, many other laboratory measurements can be made including calibration of microwave attenuators, insertion loss and gain measurements. These, and other features which enable Boeing to derive data faster and easier, have resulted in significant savings of research time.

There's one other point that should be mentioned. At Boeing's antenna test facility, Scientific-Atlanta's equipment has operated with good reliability. Whenever help is needed, Scientific-Atlanta engineers are there in a hurry.

Scientific-Atlanta will accept full responsibility for the design, construction, and manufacture for any antenna test facility that suits your needs. For details, write

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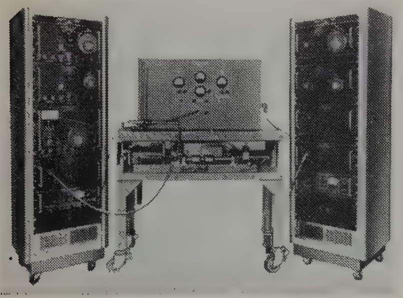
New Products

ATTENUATION MEASUREMENT SYSTEM DEVELOPED



An accurate, easy to operate system for measuring attenuation has been developed by the Weinschel Engineering Co., Kensington, Md. This system, the VM-1 Standard Attenuator Comparator, can be used over a frequency range of 100 Mc to 12,400 Mc by selection of the proper Weinschel mixers, signal sources, and oscillators. It covers directly in one step the voltage range of 40 millivolts to 0.2 microvolts; corresponding to power levels of —15 dbm to —121 dbm in a 50-ohm system. Standards laboratory accuracy can be obtained over a dynamic range exceeding 60 db within this range.

In operation, a local oscillator is used for heterodyning the signal being examined, leaving a resulting 30 Mc signal. A separate 30 Mc reference signal is fed through a very accurate piston attenuator to a comparison head. This attenuated reference signal is compared with the 30 Mc output of the mixer. The change of attenuation required in the precision piston attenuator to null the system for the two output levels of the mixer is an accurate direct measurement of the RF level change.

The VM-1 is direct reading in db, and needs no correction charts or calibration curves. The frequency drift of the RF source is compensated for by automatic frequency follower control of the local oscillator. The ease of operation of the VM-1 saves many man-hours of skilled personnel. Typical set-up time for one frequency is only 15 minutes. After this, a normally skilled operator can calibrate eight 10 db steps of a signal generator output attenuator in about three minutes.

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— m w j —

DIODE SERIES BUILT FOR DOPPLER RADAR USE

A series of low noise-figure, coaxial mixer diodes for low frequency IF doppler receiver applications from 10 to 18 kMc has been introduced by Microwave Associates, Inc., Burlington, Mass.

Two basic diode series are available. Both the MA-4124 and the reverse polarity MA-4124R exhibit maximum conversion loss of 7.5 db and a maximum output noise ratio of 20 at 50 kilocycles with a burnout rating of 0.6 ergs and IF impedance of 325 to 625 ohms.

The improved type, MA-4124A and MA-4124AR provide a maximum output noise ratio of 10 measured at 50 kilocycles.

All other electrical characteristics are identical to the 1N78. The above types are available in forward and reversed matched pairs for balanced circuit applications.

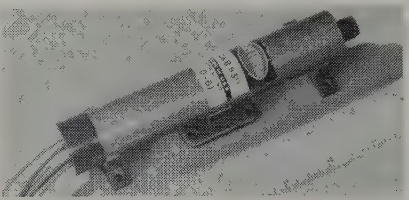
These new diodes meet the environmental requirements of MIL-S-19500B.

Circle Reader Service Card 102

— m w j —

X-BAND TUBE OPERATES OVER 8500 - 9600 MC RANGE

A new electrostatically focused type "O" - BWO, designed for applications requiring a compact voltage tunable signal source, has been introduced by Raytheon Company's Microwave & Power Tube Division, Waltham, Mass.



This rugged X-band tube, designated the QKB830, operates over a frequency range of 8500-9600 Mc with no mechanical tuning. Minimum power output is 10 mw. Electrostatic beam focusing eliminates the need for a permanent magnet, resulting in a six-inch long, light-weight tube. A control electrode is provided for low voltage pulsed or amplitude modulation.

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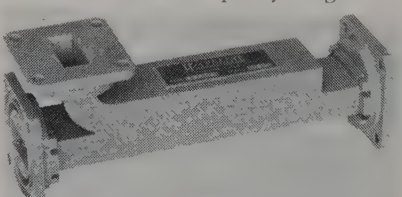
— m w j —

WAVELINE DESIGNS MINIATURE 6db DIRECTIONAL COUPLERS

Waveline, Inc., Caldwell, N. J., has designed a group of miniature six db Waveguide Directional Couplers which exhibit excellent coupling characteristics over a broadband frequency range.



The Directional Couplers combine small physical size with a coupling variation of not more than ±0.5 db. Additional special designs may be generated for miniature couplers with coupling values from 5 to 10 db. These special designs will adequately cover a 12 per cent bandwidth of frequency range with a maximum coupling variation of ±0.5 db.

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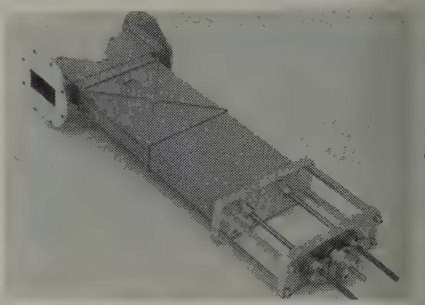
BOMAC OFFERS S-BAND PHASE SHIFTER



The BLP-123 Phase Shifter manufactured in RG48/U waveguide by Bomac Laboratories, Inc., Beverly, Mass., is a two terminal component consisting of mitered elbows, a short slot hybrid and ganged moving shorts for changing phase.

The electrical length of the unit is varied manually over a wide range. The unit is pressurized and will handle a power level approaching that of the waveguide. Connectors are UG53/U cover flanges. The moving shorts are of the double bucket design providing minimized RF leakage. Shorts are moved simultaneously by a hand-operated geared drive mechanism. A motor drive mechanism may be coupled to the drive shaft provided for more rapid and convenient phase change. Use of mitered bends minimizes line insertion length, and the unit is designed for low loss and reflection. Frequency is 2.6 - 3.95 kMc; power level, pressurized, 2.7 mw peak; and power level, not pressurized, 1.0 mw peak.

Circle Reader Service Card 104

— m w j —

NTA AMPLIFIERS DEVELOPED BY MICRO STATE

A complete line of low noise, narrow band tunnel diode amplifiers, NTA series, is included among the microwave semiconductor products available from Micro State Electronics Corp., Murray Hill, N. J.

NTA amplifiers are self-contained units which may be added directly to the front end of existing radar, troposcatter, ground and satellite communication systems. They offer a simple, economical and reliable method of improving systems performance. NTA amplifiers utilize Micro State's special low noise diodes.

They are available with 1-10 per cent bandwidths over a range of 375-1400 Mc.

Typical of these amplifiers is the NTA 615 having the following specifications: frequency, 615 Mc; bandwidth, 30 Mc; Gain, 17 db; noise figure, 4.5 db; saturation level —37 dbm input for 1 db compression; power requirements—battery operated, 5000 hours, replaceable.

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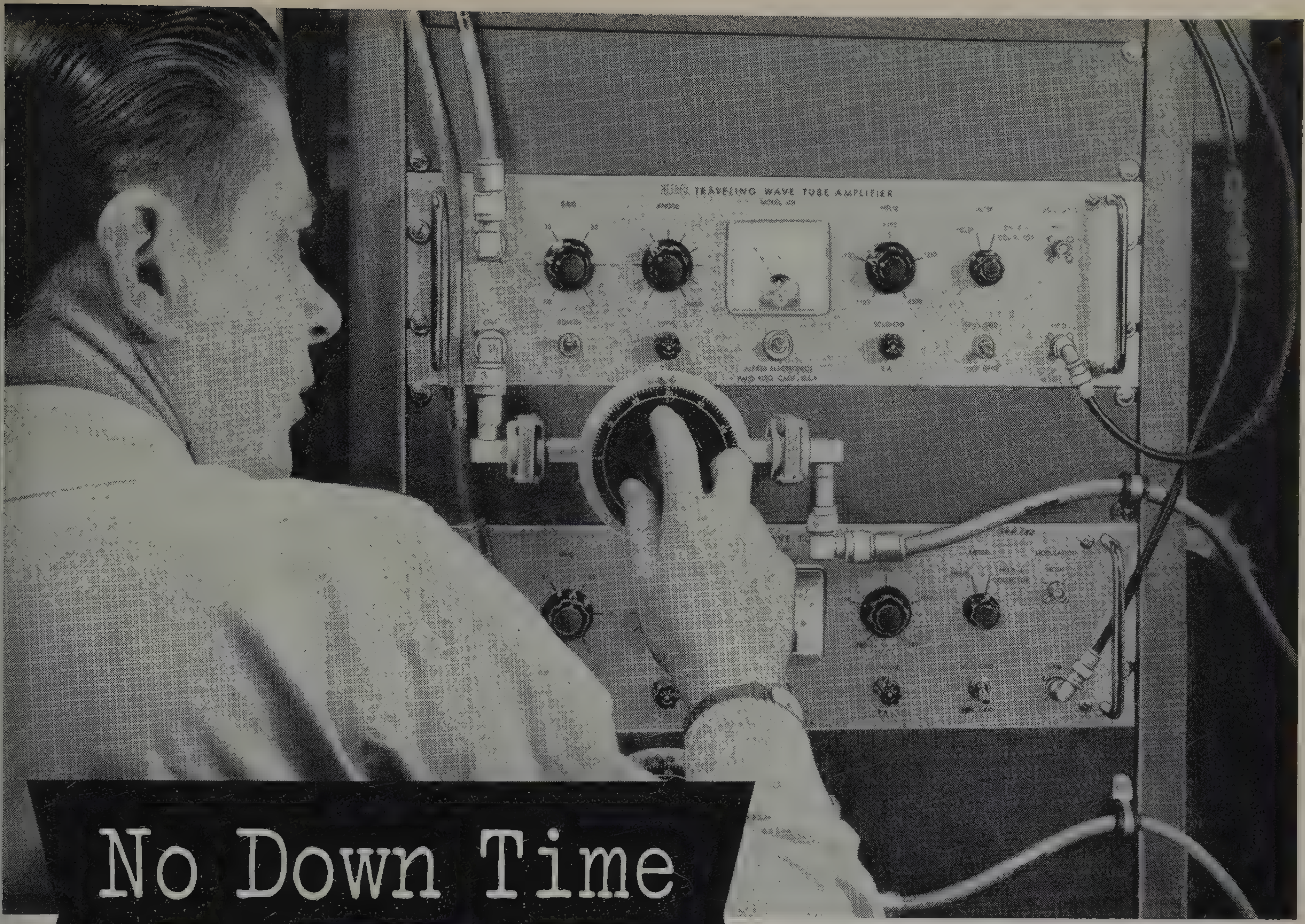


No Down Time Is Normal...

Alfred Electronics Model 504 Microwave Amplifiers, in use at Hughes Aircraft Co., Culver City, California

with ALFRED Microwave Amplifiers

These Alfred TWT microwave amplifiers have seen continuous service at Hughes for over 9 months. There has been practically no down time even for replacement of TWT tubes. Used in the RF portion of a missile testing system, the Alfred units provide high gain, wide band, flat response and low spurious modulation from 8 to 12.4 kmc. Hughes engineers praise the functional layout of the Model 504, its simple operation and reliable performance.

In short, Hughes finds the Alfred 504 Microwave Amplifiers good, sound, straightforward reliable instruments. We think you will too.

KEY SPECIFICATIONS—ALFRED MICROWAVE AMPLIFIERS

	Model	Frequency Range KMc/s	Gain db (min.)	Power Output (min.)	Price
General Purpose Amplifiers for AM, Pulse and Phase Modulation	505	1 to 2	30	10 mw	$1550.00
	501	2 to 4	30	10 mw	1490.00
	503	4 to 8	30	10 mw	1550.00
	504	8 to 12.4	30	10 mw	1490.00
	549	10.5 to 16	30	10 mw	3190.00
Medium Power Amplifiers	5-6752	1 to 2	30	1 W	$1990.00
	512	2 to 4	30 20	1 W pulsed 100 mw CW	2050.00
	502	2 to 4	30	1 W	1550.00
	5-6868	2 to 4	30	10 W	2750.00
	506	4 to 8 4.5 to 7.5	27	.5 W 1 W	2290.00
	5-542	4 to 8	30	1 W	3190.00
	*528	7 to 11	30	5 W	3490.00
	509	8.2 to 11	27	.5 W	3190.00
	510	8 to 12.4	20	100 mw	2290.00
	*527	8 to 12.4	30	2 W	3490.00
	*526	12.4 to 18	25	1 W	4950.00
High Power Amplifiers	5-6826	2 to 4	30	1 Kw Pk .01 duty cycle	$6895.00
Low and Medium Noise Figure Amplifiers	Amplifiers with low and medium noise figures are available either as packaged units or unitized for remote operation of TW tube and solenoid. Standard units provide coverage from .5 to 12.4 KMc with noise figures from 7 db up.				

*New Instrument

MANY MODELS TO CHOOSE FROM

The 504 is just one model from the industry's most complete line of microwave amplifiers. For technical details and a demonstration arranged at your convenience, contact your nearby Alfred representative or write direct.

Please address . . . Dept. 69.

ALFRED ELECTRONICS

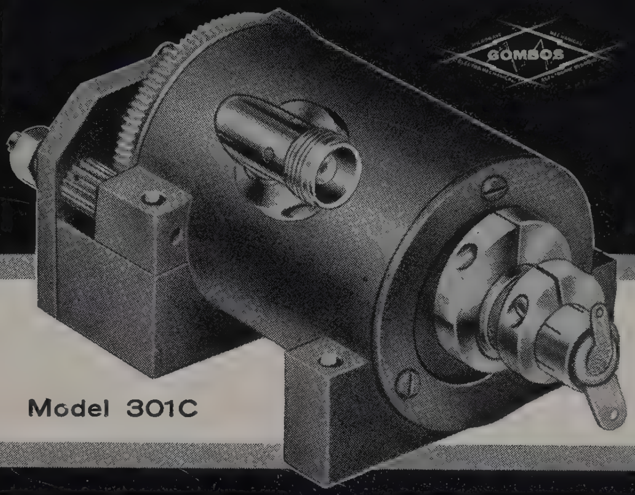
897 COMMERCIAL STREET
PALO ALTO, CALIFORNIA

5

Circle Reader Service Card 42

1 KW "C" BAND

Pulsed
TRIODE
Oscillator



Model 301C

±1 MC FM at 20 G's, 20-2000 cps
±20 KC per degree C
No mode skipping
Less than 1 MC pushing figure
Low pulling figure
Long mean-time-to-failure life
No special pulse shaping required
Milli-microseconds rise time
No magnetic shielding required

2 KW "S" Band Model 302S also available

JOHN
GOMBOS
CO., INC.
WEBRO ROAD, CLIFTON, N. J.

We are a recognized, quality manufacturer of a complete line of Triode Oscillators, Amplifiers and Multipliers from "L" Band through "C" Band. We also produce a complete line of Tunable Band Pass Filters from "L" through "Ku" Band.

WRITE TODAY *For Descriptive Literature.* We would also appreciate receiving your special requirements for active and passive Cavities, Components and Sub-systems.

Circle Reader Service Card 43

New Products

(Continued from page 78)

STANDARD PULSE GENERATOR CONSTRUCTED BY DU MONT

A standard jitter-free pulse generator termed type 404-B for general pulse generator applications has been developed and is being produced by the Instrument Department of the Allen B. Du Mont Laboratories, Clifton, N. J., Divisions of Fairchild Camera and Instrument Corp.

The instrument emphasizes ruggedized design compatible with military environmental requirements. Tested to MIL-E-16400C for shock, vibration, humidity, and temperature, the 404-B pulse generator provides minimum maintenance with no stability controls or selected components. First shipments of the new units were for test equipment in Nike Missile Radar check out.

A jitter-free generator (jitter between trigger and pulse less than three ns), its rise and fall times of 13 nanoseconds allow ultra-high frequency studies such as direct outputs into sampling scopes.

It is capable of putting 90 volts into 93 ohms or 55 volts into 50 ohms. Repetition rates range from as high as 250,000 pps down to a single, push-button actuated pulse of selected width and amplitude.

Circle Reader Service Card 106

— *m w j* —

SQUARE WAVE GENERATOR AVAILABLE FROM ALFRED

ALFRED 1KC SQ. WAVE GENERATOR
MODEL 305
FREQUENCY
SQUARENESS
AMPLITUDE
OUTPUT
OFF
ALFRED ELECTRONICS
PALO ALTO, CALIF. U.S.A.

A new square wave generator is now available from Alfred Electronics, Palo Alto, Cal., manufacturer of microwave instrumentation.

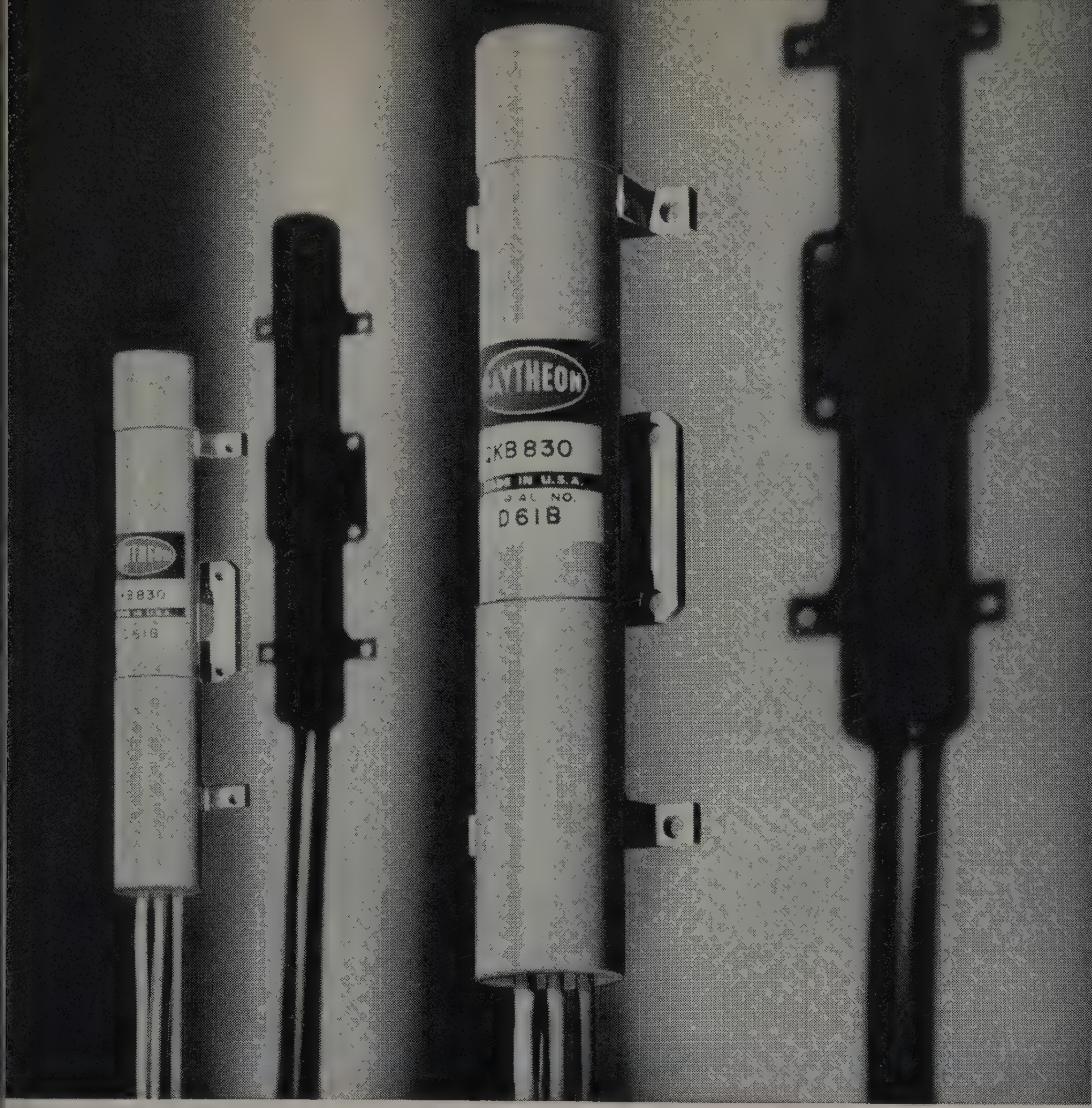
Known as the model 305, the new instrument provides up to a 60 volt peak-to-peak square wave adjustable from 850 - 1150 cps. The compact unit is designed for modulating microwave amplifiers, microwave signal generators, traveling-wave tube amplifiers, and checking response of wide band amplifiers.

Other specifications include amplitude, 0 - 60 volts peak-to-peak; grounding, direct coupled, positive ground; rise and fall time, 0.4 microsecond rise, 5 microsecond fall; frequency stability, ±0.2 per cent after a 15 minute warmup. Dimensions are 3 3/8 inches high, six inches deep, and 5 3/8 inches wide. The 2 1/2 pound unit is priced at $90, with delivery from stock.

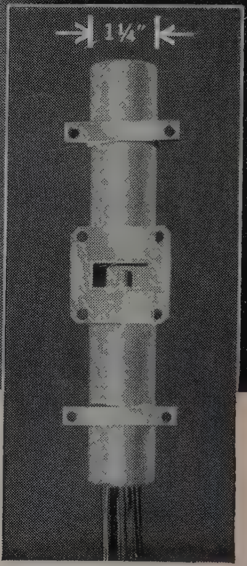
Circle Reader Service Card 107

— *m w j* —

(Continued on page 82)



QKB 830 O-TYPE BWO
1¼ inches in diamete
weighs only 1½ lbs.



Electrostatically focused BWO provides smaller, lighter X-band signal source

New Raytheon tube combines advantages of backward wave oscillators in rugged compact package ideal for airborne and missile use.

The QKB 830 is especially suitable for local oscillator service in airborne, shipboard, or ground-based equipment such as anti-jam radar receivers. A wide-range tube, it can be tuned from 8.5 to 9.6 kMc by varying a single electrode voltage.

The small size and low voltages of the QKB 830 permit its use as a direct replacement for mechanically tuned klystrons in existing systems. It is also adaptable to many other applications requiring a voltage tunable source having provision for low-voltage pulsed or amplitude modulation.

Write today for technical data or application service to Microwave and Power Tube Division, Raytheon Company, Waltham 54, Massachusetts. In Canada: Waterloo, Ontario.

QKB 830 GENERAL CHARACTERISTICS
(Typical CW Operation)

Power Output	15-30mW
Frequency	8.5-9.6 kMc
Voltage Requirements	
Tuning Voltage	150-250 Vdc
Focus Voltage	300 Vdc
Filament Voltage	6.3 V
Shock	50 G's
Cooling	convection
Overall Length	7.5 in.
Weight	1.5 lb. Max.

RAYTHEON COMPANY

RAYTHEON

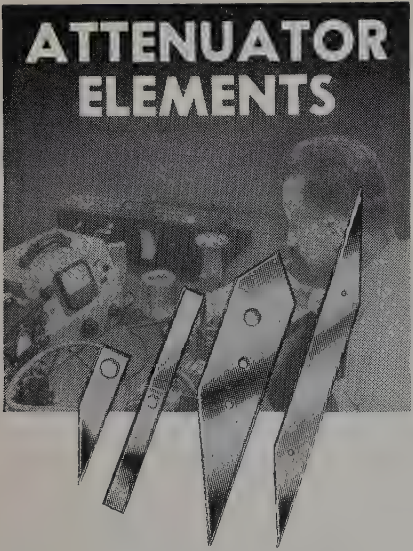
MICROWAVE AND POWER TUBE DIVISION

(Continued from page 80)

FOR
guaranteed
microwave
performance
SPECIFY
PRE-TESTED
FILMOHM

FILMCARD®

ATTENUATOR
ELEMENTS



Strict quality control of dimensional, physical and electrical characteristics, and precise pre-testing for guaranteed performance assure you of the ultra reliability of FILMOHM Filmcard attenuators in your application.

Low cost Filmcard elements, ideal as low power attenuators and terminations, are also suitable for directional coupler loads, isolation and impedance matching, crystal protectors or mode suppressors. Combining micro-thin metal film and specially laminated fibreglass, Filmcard elements provide high stability, electrical uniformity and accurate, reproducible dissipation at low R.F. power.

For Filmcard elements made to your exact specifications simply specify: attenuation; frequency range; VSWR; allowable attenuator spread with frequency. **For guaranteed microwave performance specify proven, pre-tested FILMOHM elements.**

STANDARD 5" x 12" FILMCARDS ALSO AVAILABLE FOR DEVELOPMENT WORK—Cards available in resistance values of 25 to 750 ohms/sq., ±10% tolerance. Standard values are: 50, 100, 125, 150, 180, 200, 300, 377, 400 and 500 ohms/sq. Standard thicknesses: .010, .025, .032 and .062 inches.

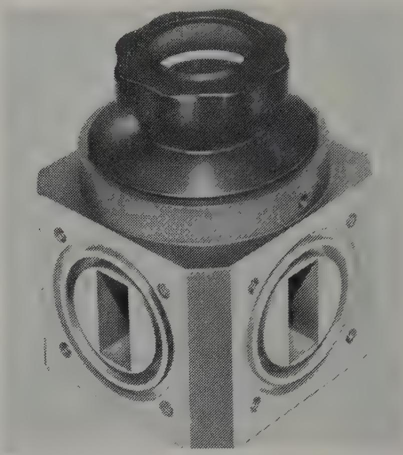
WRITE FOR CATALOG

FILMOHM

FILMOHM CORPORATION
48 WEST 25TH STREET • NEW YORK 10, N. Y.
WA 4-6605 - TWX NY 1-4892

Circle Reader Service Card 45

SWITCHES FOR 2.6 - 40 KMC FEATURE SMALL SIZE, HIGH ISOLATION



Compact, lightweight design, together with isolation characteristics previously unavailable in standard catalog units, are features of the Model 159 Waveguide Switches, announced by Radar Measurements Corp., Hicksville, N. Y.

The manually operated switches are being offered in ten types, covering the frequency range 2.6 - 40 kMc. They have been designed to meet a wide range of application requirements in microwave systems, including antenna selection, insuring radar silence while a transmitter is in operation, and elimination of interference and ground return while testing several radars from the same location.

All types within the model designation provide a minimum isolation of 60 db; in addition, switches having higher isolation ratings can be supplied on order. Insertion loss is less than 0.2 db and maximum VSWR is 1.10:1. Peak power ratings range from .031 - 3.2 mw, depending upon the particular frequency band covered.

Circle Reader Service Card 108

— *m w j* —

AVIEN INTRODUCES COLLAPSIBLE ANTENNA

The first unit, model #521A, in a new line of modular construction collapsible antennas, designed for a variety of "quick erection" functions in the 350 to 600 megacycle frequency range, has been announced by Avien, Inc., Woodside, N. Y.

In addition to quick erect, Avien reported that the #521A has the even more desirable capability of being repackable for transportation within minutes.

The new antenna is a four element array, Avien said. It measures six feet by seven feet in operation, and collapses to four feet by four feet by 20 feet. The #521A can be further broken down for storage, and is transportable. Including manual pedestal, the array weighs only 95 pounds.

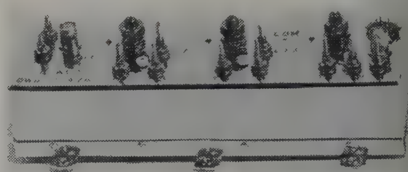
The #521A is the latest addition to Avien's line of Avien-Bogner antenna systems which are built on the patented modular construction concept invented by Richard D. Bogner, head of Avien's Antenna Department. This construction concept utilizes standardized disc and rod elements which can be built into a variety of patterns to meet a broad range of specific requirements.

Circle Reader Service Card 109

— *m w j* —

TELEMETERING PREAMPLIFIER AVAILABLE FROM COMMUNITY ENGINEERING

Used for the transmission of meter or gauge readings to remote locations, the model 3010 telemetering preamplifier from Community Engineering Corp., State College, Pa., is characterized by extremely low noise and stable gain. Noise figure averages 4.5 db over the 35 Mc band from 225 - 260 Mc. The gain is 20 db minimum. The unit is available in RF chassis without power supply, rack and panel with power supply, or in a weatherproof enclosure.



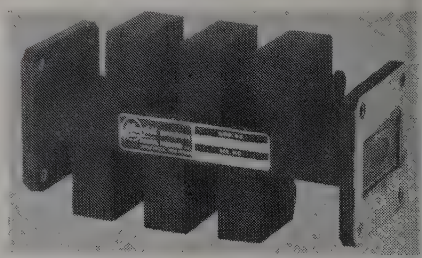
Circle Reader Service Card 110

— *m w j* —

NOTCH BAND REJECTION FILTER OFFERED BY KEARFOTT

A new tunable notch band rejection filter is now being offered by Kearfott Microwave Division, General Precision, Inc., Van Nuys, Cal.

Features of the new sealed unit rejection filter (C994-181-302) include: tunable from 9000 - 9300 Mc; rejection bandwidth, 45 db, 20 ±5 Mc; bandwidth, 3 db, of approximately 60 Mc; insertion loss, less than 0.5 db; VSWR, less than 1.2 at fo ±90 Mc; operating range, from −55 to +100°C, length, four inches; and weight, 11 ounces.



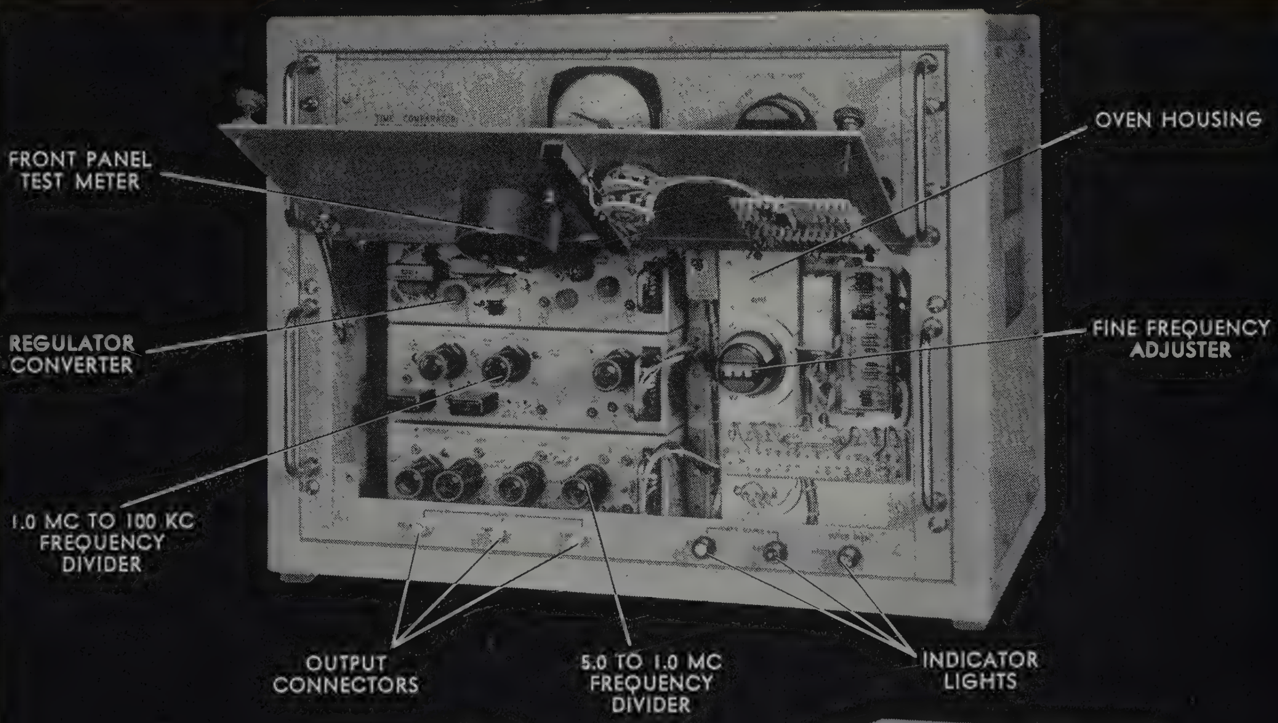
Circle Reader Service Card 111

(Continued on page 84)

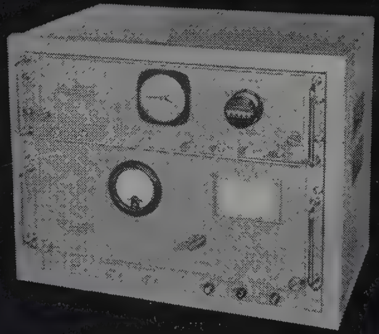
— *m w j* —

Borg Frequency Standards provide up to 1000 times the accuracy of conventional frequency comparisons

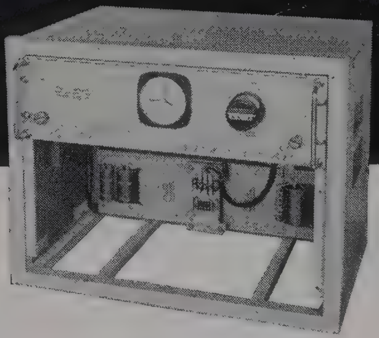
Borg Frequency and Time Standards provide time comparisons of up to 1000 times more accurate than conventional frequency comparisons. With stability of ±5 parts in 10^{10} per day these are the most accurate, most stable frequency standards commercially available. The oscillator is controlled by a 5 megacycle, 5th overtone, AT cut-quartz crystal operating in a modified Pierce circuit. The crystal resonator has an aging coefficient of less than .5 parts in 10^9 per day after 21 days of uninterrupted operation. The standards operate from a 26 ±2 volt D.C. power supply. If D.C. is unavailable, complete power supplies are also available from Borg in both portable and standby models. WRITE FOR COMPLETE DETAILS.


FRONT PANEL TEST METER
REGULATOR CONVERTER
1.0 MC TO 100 KC FREQUENCY DIVIDER
OUTPUT CONNECTORS
5.0 TO 1.0 MC FREQUENCY DIVIDER
INDICATOR LIGHTS
OVEN HOUSING
FINE FREQUENCY ADJUSTER
TIME COMPARATOR

BORG®



Front panel of standard and time comparator.



Standard with oscillator removed to reveal compact positioning of portable power supply.

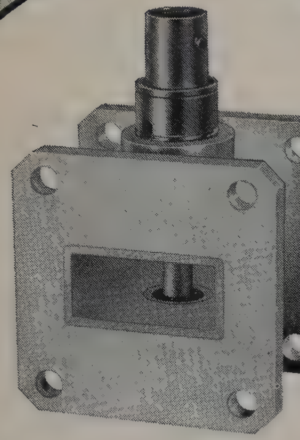
BORG EQUIPMENT DIVISION
Amphenol-Borg Electronics Corporation
Janesville, Wisconsin • Phone Pleasant 4-6616

Micropot Potentiometers • Turns-Counting Microdials • Sub-Fractional Horsepower Motors • Frequency and Time Standards

Circle Reader Service Card 46

AEL

Adds to its Ever Growing Family of
MICROWAVE CRYSTAL SWITCHES

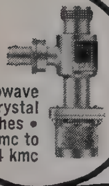


BROADBAND WAVEGUIDE CRYSTAL SWITCHES

Recent additions to AEL's line of coaxial crystal switches presently covering the spectrum from 10 mcs to 12 kmcs are Broadband Waveguide Microwave Crystal Switches operating over wide portions of the spectrum from 7 to 15 kmc, with isolations as high as 43 db. and insertion losses as low as 1.0 db. (as low as 0.3 db. at single frequencies).

Coaxial crystal detector mounts • 50 mc to 12 kmc

Waveguide Filters Band Pass and High Pass • 8.2 kmc to 40 kmc


Microwave Crystal Switches • 10 mc to 14 kmc

Horn Antennas Linearly or Circularly polarized • 1 kmc to 40 kmc

AEL®

AMER. ELECT. LABS., INC.
121 N. 7TH ST., PHILADELPHIA 6, PA.
In Canada contact: Conway Electronic Enterprises Regd. Toronto, Canada

Circle Reader Service Card 47

New Products

(Continued from page 82)

CALCIUM FLUORIDE CRYSTALS MANUFACTURED

Semi-Elements, Inc., Saxonburg, Pa., announces full production of calcium fluoride random single crystals for those who are growing their own laser crystals.

The material is the same that Semi-Elements is using to grow its laser crystals for the electronics field. Since the introduction of lasers, pure calcium fluoride raw material has been next to impossible to obtain.

Seeing a need for ultra pure calcium fluoride raw material, and since Semi-Elements already was growing large single crystals of calcium fluoride and was set up in the production of ultra pure calcium fluoride, it decided to expand these facilities.

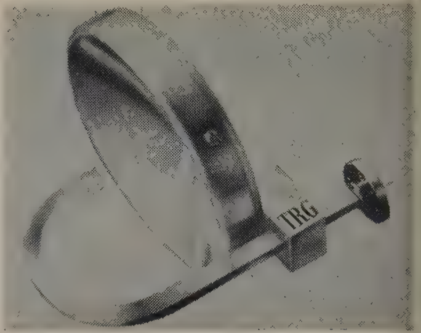
Large quantities are available immediately at prices ranging from 10 cents a gram up to 30 cents a gram, depending on the quantity ordered.

Special precautions have been taken in producing the material to keep out all rare earth impurities, since the producers of laser crystals purposely introduce rare earth impurities into the crystal when they are grown. Thus it is important that a pure material is used as a starting material.

Circle Reader Service Card 112

— *m w j* —

TRG ANNOUNCES 3 INCH PARABOLIC ANTENNA



Technical Research Group, Inc., Antenna & Microwave Dept., Somerville Mass., announces a new 3 inch diameter complete parabolic antenna for millimeter bands. The antenna is available in V, E and F bands.

The miniature antenna has a 4 degree beam width at 70 kMc. This resolution is comparable to that of a 30 inch antenna at 7 kMc. The antenna is further rated at 22 db maximum side lobe; 32.9 db gain and one inch focal length. The antenna is designed for millimeter systems and antenna test applications.

Circle Reader Service Card 113

— *m w j* —

(Continued on page 86)

For the answers to problems in the design, fabrication, and installation of antenna systems in the fields of scatter communications, missile tracking, space tracking, radar and surveillance, radio astronomy and special antenna products . . . .

ASK ASI!

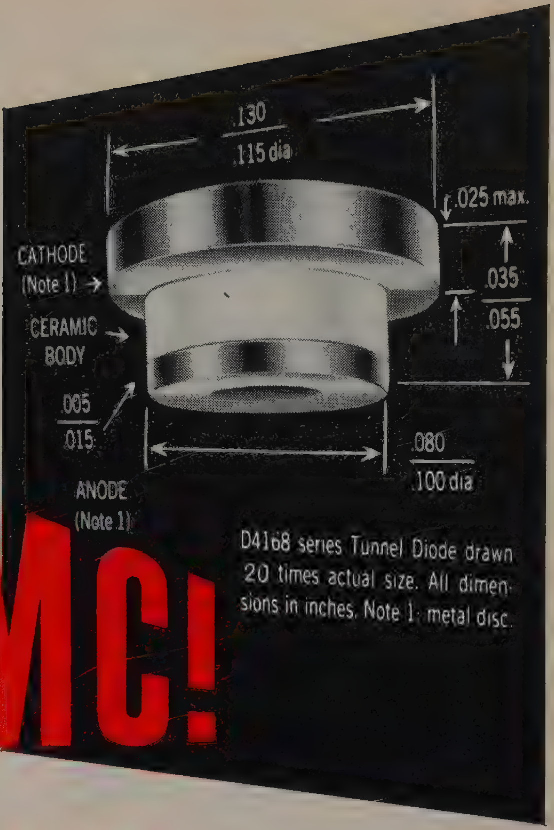
ASI

FOR FULL INFORMATION WRITE: ANTENNA SYSTEMS INC.
HINGHAM, MASSACHUSETTS

Circle Reader Service Card 48

NEW FROM SYLVANIA

6 8 & 10 KMC!



D4168 series Tunnel Diode drawn 20 times actual size. All dimensions in inches. Note 1: metal disc.

GERMANIUM **TUNNEL** DIODES

SYL-D4168C AND SYL-D4168D NOW READY FOR EVALUATION

OR SERVICE AS

oscillators—L-band to X-band ● amplifiers—at C-band
mixers—better than -90dbm tangential sensitivity at X-band

FOR APPLICATIONS IN

● common carrier equipment ● test equipment ● portable radar
● electronically scanned antenna arrays

ylvania series D4168 tunnel diodes in the min-ature “pill” package featuring performance rom 2 KMC to 10 KMC offer you a wide lati-ude in which to search out practical new appli-ations. These most recent units developed by ylvania are p-type germanium with typical eak current of 3.5 mA and typical capacitance t valley of 1.0 pf for the 10 KMC units.

ontact your Sylvania Sales Engineer or your ylvania Franchised Semiconductor Distributor or price and delivery information. Write for echnical data: Semiconductor Division, Sylvania lectric Products Inc., Dept. 356, 1100 Main treet, Buffalo 9, N. Y.

ABSOLUTE MAXIMUM RATINGS . . . Storage Temperature —40 to +100°C

ELECTRICAL CHARACTERISTICS AT 25°C

Type	Typ. Peak Current, i_p (mA)	Typ. Capacitance at Valley (pf)	Min. Peak to Valley Current Ratio	Min. Measured Frequency of Osc. (KMC)	Typ. Series Resistance (ohms)
D4168	3.5	3.5	5	2	2
D4168A	3.5	2.5	5	4	4
D4168B	3.5	2.0	5	6	6
D4168C	3.5	1.5	5	8	8
D4168D	3.5	1.0	5	10	10

Negative resistance—70Ω typ. Series inductance—0.25 mμh typ.

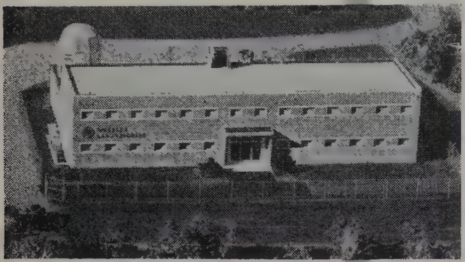
SYLVANIA

SUBSIDIARY OF
GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

WHEELER LABORATORIES, INC.
ON LONG ISLAND/A SUBSIDIARY OF HAZELTINE CORPORATION

Main Office and
Microwave Laboratory
Great Neck, New York



Antenna Laboratory
and Test Range
Smithtown, New York

In the field of microwave engineering, Wheeler Laboratories occupies a unique position as an industrial laboratory devoted exclusively to consulting and development.

As a service to many prominent laboratories and manufacturers, WL designs radar and communication antennas, waveguide components, and microwave assemblies. Your inquiries are invited.

WL

HAROLD A. WHEELER
and Engineering Staff

Circle Reader Service Card 49

PRECISION WAVEGUIDE BENDING
TO YOUR SPECIFICATIONS

Bends, Twists, Offsets, Coils, Transitions, Fabrications and complete assemblies to your prints.

Specialty
AUTOMATIC MACHINE
CORPORATION

80 CAMBRIDGE ST.
BURLINGTON, MASS.
TEL. BRowning 2-0800

Circle Reader Service Card 50

New Products

(Continued from page 84)

HIGH-POWER RF CALORIMETER AVAILABLE FROM HEKTOR SCIENTIFIC

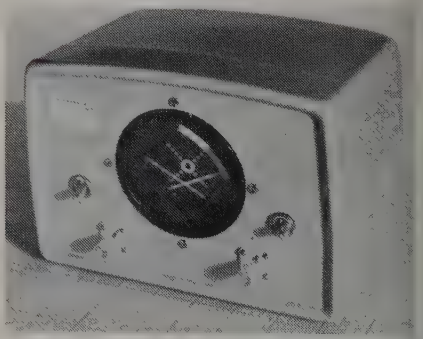
A precision, self-contained, portable liquid calorimeter with average power capacity of 30 kw is available from Hektor Scientific Co., Norwood, Mass.

Accuracy is stated as better than five per cent. The distilled water system is sealed and comes in contact only with stainless steel or inert materials. Power is read directly by means of a precision calibrated bridge circuit. The unit is supplied only with matched loads.

Circle Reader Service Card 114

— m w j —

SRL ANNOUNCES AUTOMATIC FREQUENCY METER & MONITOR



Somerset Radiation Laboratory, Inc., Stirling, N. J., a designer and manufacturer of automatic microwave instruments, standards, and systems, offers the series AFM Automatic Frequency Meter.

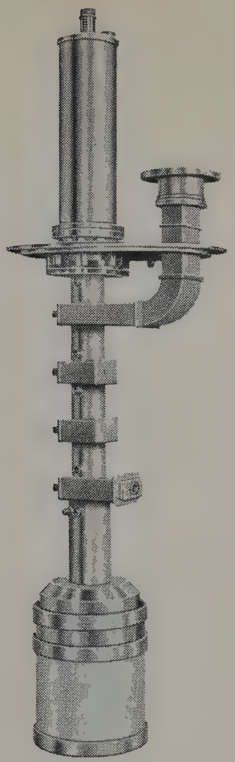
The simple, fully-automatic, but economical instrument can be used in conjunction with commonly-available microwave instruments for continuously monitoring microwave frequencies.

The AFM indicator employs a sensitive, aircraft-type, dual-meter movement that permits reading frequency directly and unambiguously at the intersection of one pointer whose position is a function of frequency and power level with another pointer whose position is solely a function of power level.

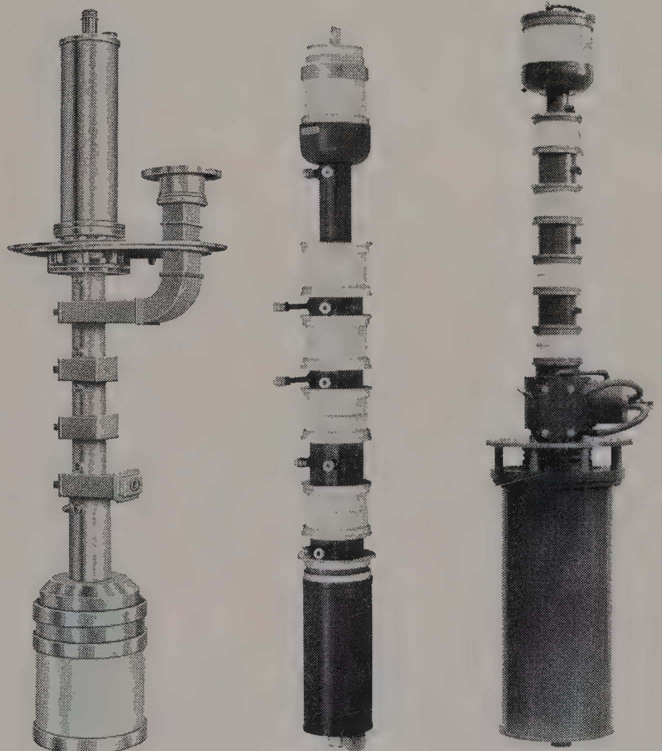
Circle Reader Service Card 115

— m w j —

(Continued on page 94)



Most companies think there's only one way to design a klystron.



But Eimac knows there are three.

Some rf ranges and requirements call for an internal cavity klystron. Others, an external one. For still others, a combined internal-and-external cavity is best. That's why Eimac designs klystrons *all three ways.* (And why it has more high power klystrons operating throughout the free world than all other makers combined.) Fact is, that's how Eimac designs *every* tube: to meet your specific needs. For data on Eimac klystrons shown above (4KP40,000SQ, internal cavity; 4K50,000LQ, external cavity; 5K210,000LQ, combined internal-and-external cavity) contact your Eimac representative or write: Power Klystron Division, Eitel-McCullough, Inc., San Carlos, Calif.

Circle Reader Service Card 51

Abstracts from Russian Technical Literature... of interest to microwave engineers

Translations of complete papers can be made available by contacting Morris D. Friedman, Inc., c/o "the microwave journal," 1330 Beacon Street, Brookline, Massachusetts. Prices are dependent upon length of paper.

ELEKTROSVIAZ', VOL. 14, NO. 10, (1960)*

Iu. I. Kaznacheev:

WAVEGUIDE LINES WITH LOW LOSSES.

pp. 47-52

The basic results of an investigation of waveguide lines when signals at a H_{01} mode are transmitted are explained. The characteristics of the most promising waveguides are compared.

(6F, 15R)

**Electrical Communications. (ES).*

—*mwj*—

ELEKTROSVIAZ', VOL. 14, NO. 11, (1960)

Iu. I. Kaznacheev:

WAVEGUIDE LINE ELEMENTS AND APPARATUS.

pp. 48-53

Results are explained of an investigation to produce waveguide elements and apparatus of waveguide lines as well as to select a method of modulation and the final apparatus.

(6F, 12R)

—*mwj*—

IT, NO. 6, (1960)

G. Ia Mirskii:

PERFECTION OF THE METHOD OF MEASURING RESONATOR QUALITY IN A CIRCUIT WITH A LECHER WIRE.

pp. 47-49

In a number of different methods used to determine the quality of resonators in the microwave region, the method of measurements at the "half-power" points of the resonance curve of the cavity is widely known. The fundamental deficiencies of this method are the tedium in recording the curve $k = \psi(f)$, the distortion in the upper part of the curve due to errors in measuring large values of the SWR, contact losses and losses in the element coupling the cavity to the channel. These deficiencies can be diminished to a considerable extent by determining the resonator quality according to the bandwidth not at the $k_1/_2$ level but at an arbitrary level k_x found somewhat above the resonance value k_0. This level is selected in the measurement of each cavity so that only the lower part of the resonance curve would be recorded to comparatively low values of the SWR and the bandwidth at the selected level would not be too narrow.

(3F, 6R)

—*mwj*—

IT, NO. 7, (1960)

V. I. Pronenko, L. N. Brianskii:

DEVICE TO MEASURE THE SWR OF A GENERATOR.

pp. 48-49

It is expedient to use a convenient and simple device to measure the SWR in the long-wavelength part of the centimeter band which appears to be a mobile short-circuiting, contactless waveguide piston along whose axis of symmetry there is a longitudinal orifice with diameter less than the critical. A strip of coaxial line is placed in this orifice, which terminates at one side to the coupling loop and on the other to a wideband detector chamber. The section of the tube formed in the body of the piston (from the end face to the loop coupler) is a limiting attenuator.

(1F, 1T, 2R)

—*mwj*—

IT, NO. 4, (1960)

A. N. Akhiezer:

WAVEGUIDE POWER DIVIDER WITH ELLIPTIC POLARIZATION.

pp. 50-52

The waveguide power divider considered herein is based on a new principle, the conversion of the initial mode into an elliptically polarized H_{11} mode in a circular waveguide and the subsequent reverse transition to a H_{01} mode in a rectangular waveguide.

(4F, 1T, 3R)

—*mwj*—

IT, NO. 1, (1960)

M. E. Gertsenshtein, L. N. Brianskii:

ELIMINATION OF MISMATCH ERRORS BY USING PHASE SHIFTERS.

pp. 48-51

The purpose of the present paper is to explain that the method proposed previously of using one phase-shifter to eliminate mismatch error completely in measurements of generator power or receiver sensitivity can be applied to more complex channels having several cycles of paired reflections and to analyze the question of errors because of non-ideal phase shifters.

(6F, 6R)

—*mwj*—

IT, NO. 9, (1960)

D. I. Mirovitskii, G. G. Valeev, I. F. Budagian:

MEASUREMENT OF THE COMPLEX REFLECTION COEFFICIENT OF A DIELECTRIC MATERIAL.

pp. 51-53

The device is intended to measure the complex reflection coefficient of a plane-parallel sheet of material located in free space in a narrow wave packet generated by an axial emitter antenna, and it is a system of surface wave transmission lines forming a directional coupler, a balancing unit and a phase shifter. A regulated reference signal and the unknown signal reflected by the sample being measured are compared in the balancing unit.

(2F, 11R)

—*mwj*—

IT, NO. 9, (1960)

A. I. El'kind:

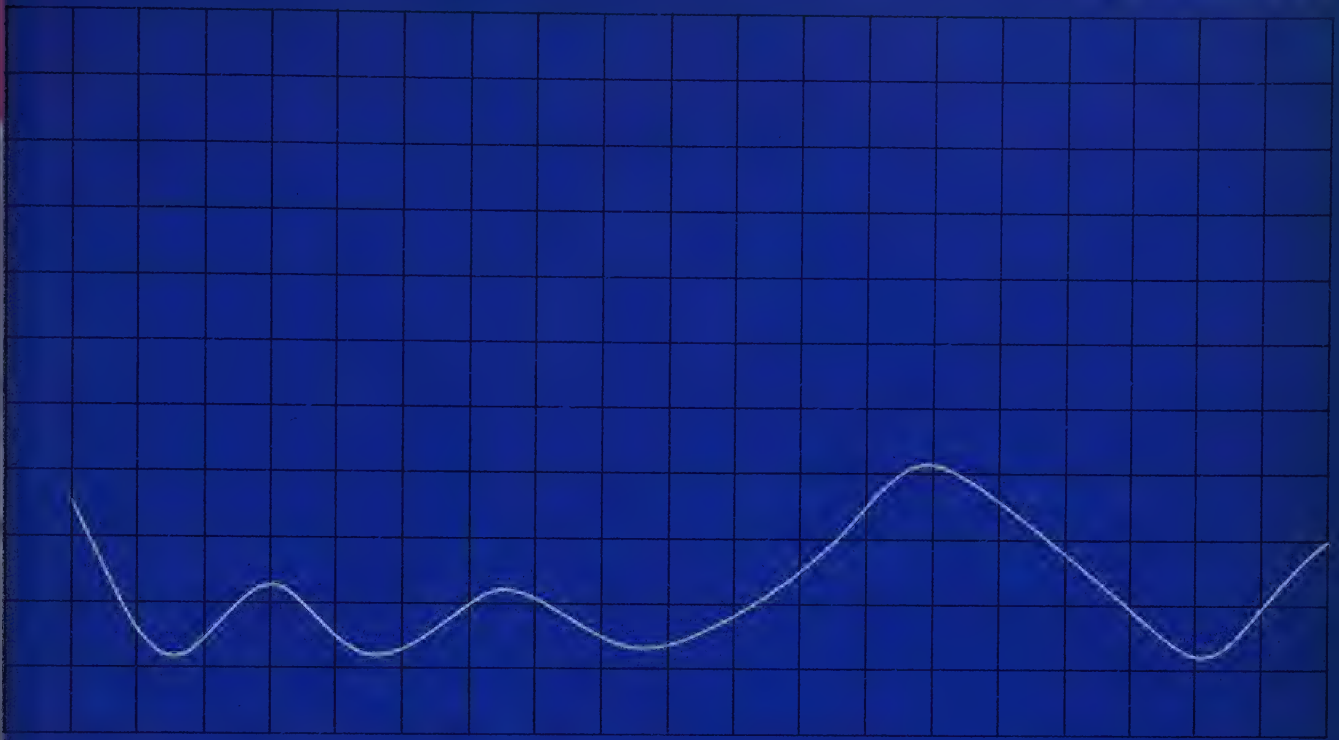
SLOTLESS MEASURING LINE.

pp. 44-48

Below is considered the use of a line with a mobile short-circuiter to measure the SWR and total impedance of microwave loads. Questions of the transition

(Continued on page 93)

BULLETIN 600



OLOMETERS, THERMISTORS and MOUNTS

LOW VSWR

WIDE FREQUENCY RANGE

HIGH EFFICIENCY FOR ACCURATE DETECTION & POWER MEASUREMENT

PRD
ELECTRONICS, INC.
A Subsidiary of Harris-Intertype Corporation
Formerly, Polytechnic Research & Development Co., Inc.

202 Tillary Street, Brooklyn 1, N. Y.
ULster 2-6800
1608 Centinela Ave., Inglewood, Cal.
ORegon 8-9048

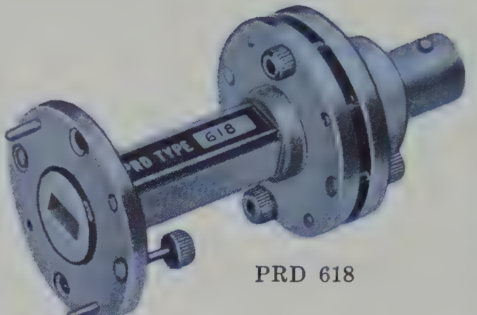
HARRIS
INTERTYPE
CORPORATION

PRD BOLOMETERS, THERM

WAVEGUIDE

Bolometer Mounts

These units are used for low power bolometric detection in waveguide systems from 18.0 to 40.0 KMC/sec. They are designed to utilize the PRD 617 Bolometer (see back cover), providing a means for making accurate relative power and attenuation measurements. High sensitivity and reliable square law operation are typical of the PRD 618 and 620 series mounts with 617 Bolometers.

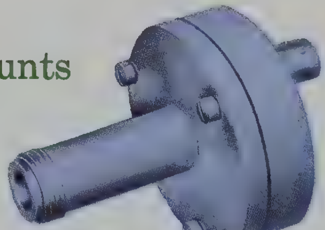


PRD 618

TYPE NO.	EQUIVALENT WAVEGUIDE TYPE	WAVEGUIDE SIZE (Inches - I.D.)	FREQUENCY RANGE (kmc/sec)	BOLOMETER TYPE (one supplied)	FLANGE TYPE	OUTPUT CONNECTOR	OVERALL LENGTH (inches)
618	RG-96/U	0.280 x 0.140	26.5 to 40.0	PRD 617	UG-381/U	BNC Jack	2 15/32
618-F1	RG-96/U	0.280 x 0.140	26.5 to 40.0	PRD 617	UG-599/U	BNC Jack	2 15/32
620	RG-66/U	0.420 x 0.170	18.0 to 26.5	PRD 617	UG-425/U	BNC Jack	2 17/32
620-F1	RG-66/U	0.420 x 0.170	18.0 to 26.5	PRD 617	UG-595/U	BNC Jack	2 17/32

COAXIAL

Thermistor and Bolometer Mounts



PRD 627

PRD 627 and PRD 628 Fixed-Tuned Coaxial Mounts offer a means of precision absolute r-f power measurements in the range of 0.5 to 10.0 KMC. With appropriate transitions, they may also be used in waveguide systems. Because of the high order of accuracy obtainable with these mounts, they are especially valuable as secondary power standards in the calibration of other equipment. These mounts provide a low VSWR over the entire band without recourse to variable external or internal tuning.

TYPE NO.	COAXIAL LINE SIZE (inches)	INPUT CONNECTOR	OUTPUT CONNECTOR	OVERALL LENGTH	BOLOMETER RECOMMENDED TYPE (not supplied)
627-A	⅜	Type N Jack	BNC Jack	2 13/16	631-C
627-AM	⅜	Type N Plug	BNC Jack	2 11/16	631-C
627-AC1	⅜	Type C Jack	BNC Jack	2½	631-C
628-A	⅜	Type N Jack	BNC Jack	2 13/16	631-D or 631-G Thermistor
628-AM	⅜	Type N Plug	BNC Jack	2 11/16	631-D or 631-G Thermistor
628-AC1	⅜	Type C Jack	BNC Jack	2½	631-D or 631-G Thermistor
628-B	⅜	Type N Jack	2 Terminal	2½	631-F (supplied)

TYPE NO.	FREQUENCY RANGE (kmc/sec)	MAXIMUM AVERAGE R-F POWER (mw)	MAXIMUM VSWR	OPERATING RESISTANCE (ohms)	NOMINAL BIAS CURRENT (ma)	TEMPERATURE COEFFICIENT
627-A	0.5—10	1	1.5	200	4.5	+
628-A	0.5—10	10 or 100*	1.5	200	12 or 35	(+or—)*
628-B	0.5—10	100	1.5	200	35	+

Electrical characteristics of 627-AM and 627-AC1 same as 627-A
Electrical characteristics of 628-AM and 628-AC1 same as 628-A
*628-A can be used with either the 631-D Film Bolometer (100 mw) or 631-G Thermistor (10 mw)

Thermistor Mounts

These are accurate r-f power m
ing devices for waveguide bands fr
to 26.5 KMC...either modulated
signals. For accurate direct-read
power with these mounts, PRD
Universal Power Bridge is recomm
These mounts are capable of op
over a power range of from less th
microwatts to 10 milliwatts...this
further extended upwards by use
brated attenuators such as the PR
series.

TYPE NO.	EQUIVALENT WAVEGUIDE TYPE	WAVEGUIDE SIZE (inches)
644	RG-48/U	3 x 1½
645	RG-49/U	2 x 1
646	RG-50/U	1½ x ¾
647	RG-51/U	1¼ x ⅝
643-A	RG-52/U	1 x ½
648	RG-107	.622 x .311
607	RG-66/U	.420 x .170
607-F1	RG-66/U	.420 x .170

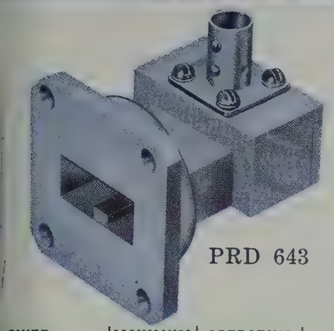
Crystal and Bolometer

In general, the same remark
to these that apply to the waveguid
tal and bolometer mounts above.
axial series can, with proper tran
such as PRD 354, be utilized in wav
systems. Each of the series has b
signed to use either a crystal or th
610-A Bolometer, depending on the
range to be measured. The -S1 v
are specifically designed for use as

TYPE NO.	COAXIAL LINE SIZE (inches)	FREQUENCY RANGE (kmc/sec)	TYPE
612-A	⅜	1 to 10	Double-tune
612-AS1*	⅜	1 to 10	Double-tune
613	⅜	1 to 12	Untuned
613-M	⅜	1 to 12	Untuned d-c return
613-MS1*	⅜	1 to 12	Untuned d-c return
613-S1*	⅜	1 to 12	Untuned
622	⅜	1 to 12	Untuned d-c return

*By-pass capacitance 20-40$\mu\mu$f

RS and MOUNTS

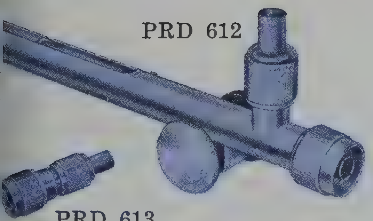


PRD 643

OWER ANGE	MAXIMUM VSWR	OPERATING RESISTANCE	TEMPERATURE COEFFICIENT
n 100 micro- 10 milliwatts	1.5*	200 ohms	Negative

r PRD 648 Mount, 2.0 for PRD 607 and 607-F1

FREQUENCY RANGE (kmc/sec)	FLANGE TYPE
2.6 to 3.95	UG-53/U
3.95 to 5.85	UG-149/U
5.4 to 8.2	UG-344/U
7.05 to 10	UG-51/U
8.2 to 12.4	UG-39/U
12.4 to 18.0	UG-419/U
18.0 to 26.5	UG-425/U
18.0 to 26.5	UG-595/U



PRD 612

PRD 613

CONNECTORS INPUT	OUTPUT	OVERALL LENGTH (inches)
Type N Plug	BNC Jack	7¼
Type N Plug	BNC Jack	7¼
Type N Plug	BNC Jack	2¼
Type N Plug	BNC Jack	2¼
Type N Plug	BNC Jack	2¼
Type N Plug	BNC Jack	2¼
Type N Plug	Type N Jack	2¹³⁄₃₂

Crystal and Bolometer Mounts

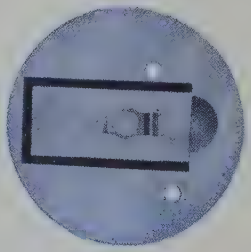
PRD 616

PRD 601

This series is designed for use with crystals or bolometers for the detection of CW, squarewave, pulse, and frequency modulated microwave signals. With crystals, they may be used to monitor power level or modulation waveshape, as constant level or sensitive null indicators, or as general purpose indicators of microwave signals. At low level, the square law characteristic of the crystal will give very accurate measurements of relative power or attenuation. If provision is made for injection of a local oscillator signal, mixer operation is also possible. Bolometers are used with these mounts for accurate wide range measurements of relative power or attenuation.

TYPE NO.	CLASS	EQUIVALENT WAVEGUIDE TYPE	WAVEGUIDE SIZE (inches)	FREQUENCY RANGE (kmc/sec)	FLANGE TYPE	OUTPUT CONNECTOR	RECOMMENDED DETECTOR	LENGT (inche
601	Fixed	RG-52/U	1 x ½	8.5 to 9.6	UG-39/U	BNC Jack	1N23B crystal	2¹⁄₁₆
616-A	Tunable	RG-107/U	0.622 x 0.311 I.D.	12.4 to 18.0	UG-419/U	BNC Jack	1N26 or 1N78 crystal or PRD 614 Bolometer	6¹³⁄₁₆ to 7⅞
6604	Fixed	RG-107/U	0.622 x 0.311 I.D.	12.4 to 18.0	UG-419/U	BNC Jack	1N26, 1N78 or 1N286 crystal, or PRD 614 Bolometer	1½
621-A	Tunable	RG-66/U	0.420 x 0.170 I.D.	18.0 to 26.5	UG-425/U	BNC Jack	1N26 crystal or PRD 614 Bolometer	6²³⁄₃₂ to 7⅜
621-AF1	Tunable	RG-66/U	0.420 x 0.170 I.D.	18.0 to 26.5	UG-595/U	BNC Jack	1N26 crystal or PRD 614 Bolometer	6²³⁄₃₂ to 7⅜
6605	Fixed	RG-66/U	0.420 x 0.170 I.D.	18.0 to 26.5	UG-425/U	BNC Jack	1N26, 1N78 or 1N286 crystal or PRD 614 Bolometer	1⁵⁄₁₆
6605-F1	Fixed	RG-66/U	0.420 x 0.170 I.D.	18.0 to 26.5	UG-595/U	BNC Jack	1N26, 1N78 or 1N286 crystal or PRD 614 Bolometer	1⁵⁄₁₆
6606	Fixed	RG-96/U	0.280 x 0.140 I.D.	26.5 to 40.0	UG-381/U	BNC Jack	1N53 crystal	1³⁄₁₆
6606-F1	Fixed	RG-96/U	0.280 x 0.140 I.D.	26.5 to 40.0	UG-599/U	BNC Jack	1N53 crystal	⅞

Bolometers and Thermistors



PRD 631-C

For use with the PRD 627 and 628 mounts, PRD manufactures bolometers and thermistors. These are the PRD 631-C, 631-D, 631-F and 631-G. All are designed for accurate measurement of r-f power in the frequency range from 0.5 to 10.0 KMC. The difference between the members of the 631 series is as follows: 631-C is a Wollaston wire type bolometer, for maximum average r-f power of 1 milliwatt; 631-D and 631-F are thin film bolometers for power measurements in the 100 mw range; 631-G is a thermistor, utilizing semiconductor beads, for the 10 mw power range. When mounted, these units provide a low VSWR over their entire specified frequency ranges without tuning.

TYPE NO.	BOLOMETER MOUNT TYPE NO.	FREQUENCY RANGE (kmc/sec)	MAXIMUM AVERAGE R-F POWER (mw)	OPERATING RESISTANCE (ohms)	BIAS CURRENT (ma)	TEMPERATURE COEFFICIENT
631-C	627-A	0.5 to 10	1	200	4 to 5	+
631-D	628-A	0.5 to 10	100	200 ± 20	35	+
631-F*	628-B	0.5 to 10	100	200	35	+
631-G	628-A	0.5 to 10	10	200 ± 20	12	—

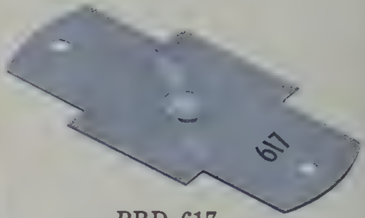
*With special temperature compensating element

OTHER TYPES of BOLOMETERS

These are platinum wire bolometers with highly accurate square law characteristics. They are used in place of crystals whenever precise relative microwave power measurements are required . . . for accurate slotted line measurements, for power monitoring, and for attenuation and loss measurements. In conjunction with PRD 277-B Standing Wave Amplifier, they act as detectors of amplitude-modulated power. CW power detection is measured with the aid of the PRD 650-B Universal Power Bridge.

PRD 614

PRD 610

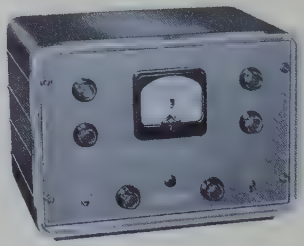


PRD 617

TYPE NO.	FREQUENCY RANGE (kmc/sec)	INTERCHANGEABLE WITH CRYSTAL	FOR USE WITH TYPES	BIAS CURRENT (ma)	OPERATING RESISTANCE (ohms)	MAXIMUM AVERAGE R-F POWER (mw)	TEMPERATURE COEFFICIENT
610-A	0 to 12.4	1N23	250, 612, 613	4 to 5	200	1	+
614	12.4 to 26.5	1N26	210, 211, 616, 621	4 to 5	200	1	+
609	12.4 to 40.0	608	253	4 to 5	200	1	+
617	18 to 40	. . . .	618, 620	4 to 5	200	1	+

Universal Power Bridge

Utilized in conjunction with any of the bolometers, thermistors, and mounts described here, the PRD 650-B presents an accurate means for the measurement of absolute r-f power levels.


650-B

For further information on bolometer theory and design, write for PRD Report Vol. 1, No. 4. For further specifications, descriptions, and operational data, write for your copy of the giant PRD catalog. Applications engineering on request.

PRD
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(Continued from page 88)

during lowering of the measured SWR from the resonance method of measurement to measuring line methods, of the difference methods of measuring low SWR by lines with a different kind of coupling, are inadequately discussed in the literature. The method of measuring a low SWR by slotless measuring lines is not described. It is, consequently, expedient to present a systematic description of slotless lines as a class of devices.

(4F, 5R)

— m w j —

IT, NO. 2, (1960)

D. I. Mirovitskii:

ON THE MEASUREMENT OF REFLECTION COEFFICIENTS OF DIELECTRIC SAMPLES IN FREE SPACE.

pp. 39-44

Two limiting cases are investigated below: 1) Sample has such dimensions that the irradiation of its edges can be neglected but it is impossible to consider the incident wave as planar; 2) the sample is so small that the incident wave can be considered planar, where the sample edges are irradiated in a noticeable manner.

The intermediate case when both the curvature of the phase front of the wave and the wave diffraction by the sample play a part has been investigated experimentally. *(6F, 13R)*

(6F, 13R)

— m w j —

ES, 14(12) (1960)

V. B. Shteinshleiger:

QUANTUM MICROWAVE PARAMAGNETIC AMPLIFIERS. I.

pp. 38-44

The physical operating principles of quantum paramagnetic amplifiers are analyzed, their apparatus is described, and appropriate quantitative characteristics are presented. (Part II in ES, 16(1) (1961))

(5F, 2R)

— m w j —

RT, 15(11) (1960)

P. N. Andreev, G. A. Napolova, M. S. Neiman:

pp. 26-33

The development and experimental investigations of decimeter and meter wavelength self-oscillators of resnatron type with power from 40 - 100 Kw in the continuous region are described.

(PROBABLY MOSCOW AVIATION INST.) *(7F, 3T, 5R)*

— m w j —

RIE, 5(11) (1960)

N. A. Semenov:

COMPUTATION OF THE WAVE PARAMETERS OF A DIELECTRIC WAVEGUIDE.

pp. 1828-36

The fundamental parameters characterizing the propagation of the eight simplest types of waves along a circular isotropic dielectric waveguide with arbitrary ϵ and μ are calculated. The properties of the waves of different types are discussed.

(12F, 1T, 7R)

— m w j —

RIE, 5(11) (1960)

B. M. Bulgakov, V. P. Shestopalov, I.A. Shishkin, I. P. Iatsimenko:

SYMMETRIC SURFACE WAVES IN A SPIRAL WAVEGUIDE PLACED IN A FERRITE MEDIUM.

pp. 1818-27

Dispersion equations for a spiral waveguide in a ferrite medium in the presence of a longitudinal magnetizing field have been obtained and investigated; the power flux in the system has been determined. It is shown that forward and reverse waves in such a system are propagated in a different manner depending on the permanent magnetic field directed along the system axis.

KHAR'KOV UNIV. *(6F, 12R)*

— m w j —

RIE, 5(11) (1960)

V. M. Lopukhin, A. S. Roshal', G. A. Kuz'mina:

LINEAR THEORY OF TWO-BEAM BWT AND TWT AMPLIFIERS.

pp. 1837-47

A linear theory is presented for two-beam BWT and TWT amplifiers. It is established that the processes in tubes with considerable current densities are similar to processes in electron-wave tubes, for low currents, the processes are similar to BWT and TWT.

Two-beam TWT amplifiers are more promising than two-beam BWT amplifiers.

MOSCOW UNIV. *(8F, 5R)*

— m w j —

RIE, 5(11) (1960)

G. D. Lobov:

MIXING OF TWO MICROWAVE SIGNALS BY USING A GAS-DISCHARGE DETECTOR.

pp. 1848-56

A theory of the operation of a gas-discharge detector in the microwave oscillation mixing region is proposed. Underlying the theory is the assumption on the change in the electron temperature upon application of the microwave power, which in turn changes the discharge current through the gas-discharge tube. Relations are derived which permit an estimate of the frequency properties of a gas-discharge detector, its response in the frequency-mixing region, and the value of the optimum heterodyne power.

The deductions of the theory are confirmed experimentally.

MOSCOW POWER INST. *(6F, 3T, 7R)*

— m w j —

RIE, 5(11) (1960)

T. P. Volkova, N. P. Kerzhentseva:

ON THE PROPAGATION OF FAST MODES IN A SPIRAL WAVEGUIDE WITH A DIELECTRIC SHELL AND METAL SHIELD.

pp. 1811-17

Fast intrinsic modes of a spiral waveguide in dielectric and metal shells are investigated. The dependence of the eigenvalues of the non-symmetric modes on the dielectric thickness is analyzed. The possibility is indicated of increasing the attenuation of the H_{om} modes for specific dielectric thicknesses.

IRE AN USSR *(4F, 1T, 5R)*

— m w j —

RADIOTEKHNIKA I ELEKTRONIKA, 5(9) (1960)

L. N. Loshakov:

ON THE THEORY OF AN ELECTRONIC MICROWAVE DEVICE WITH INTERACTION IN THE TRANSVERSE DIRECTION.

pp. 1448-1457

Results are explained of a preliminary investigation of a waveguide model of an electronic microwave device which is different in that the electron stream moves perpendicularly to the direction of the power flux. *(1F, 6R)*

— m w j —

RADIOTEKHNIKA I ELEKTRONIKA, 5(6) (1960)

M. V. Vamberskii:

ELECTRODYNAMIC COMPUTATION OF A RIDGED COAXIAL.

pp. 930-937

General expressions are found for the electromagnetic field components in a ridged coaxial. The solutions of the wave equation are expressed as cylindrical functions of half and integral order.

Relations are found for the fundamental TE type wave, between the cylindrical functions describing the field configuration and also graphs are constructed for the determination of the wave number k_c and the critical wavelength λ_{cr}. Regions of circular polarization of the magnetic field vector are investigated.

The use of ridged coaxial to produce ferrite resonance gates in the decimeter wave band is analyzed. An expression is obtained by the method of the theory of small perturbations for the gain of the gate. Computational results on the gate range are compared with experimental results. *(10F, 5R)*

— m w j —

ELINT

ELectronic INTelligence — or more precisely, receiving systems for the collection of ELINT information — are of particular interest at ATI. Emphasis in current developments is on high sensitivity, combined with high probability of intercept for pulse signals.

While wide-open "crystal-video" receivers exhibit excellent intercept probability characteristics, they provide inadequate sensitivity for many operational situations. The sensitivity of this class of receivers can be increased significantly through the use of broad-band preamplification. The available tangential sensitivity is given by $S_{max} \approx [-110 + F_{db} + 5 \, \mathrm{Log}_{10} (2 B_R B_V)]$ dbm B_R, the RF bandwidth, and B_V, the video bandwidth are in Mc. The relation holds when B_R is at least twice B_V. F_{db} is the noise figure of the RF preamplifier, in decibels. The minimum preamplifier gain required to realize S_{max} is given by $G_{min} = | S_{max} - S_x | + 3\text{db}$, where S_x is the tangential sensitivity of the crystal-video section, in dbm.

Our available ELINT receiving systems for frequencies ranging from 30 Mc to 40 kMc may be useful for your application directly or with minor modifications. If not, our staff of specialists in this area will be glad to tailor a new system to your particular operational situation. A project-oriented "chain of command" allows us to deliver on a short time scale.

ATI

AREAS OF SPECIALIZATION:
- ELINT Receiving Systems
- Deceptive Electronic Countermeasures
- Broad-Band Amplification
- Ionosphere Research Instrumentation
- Radio Astronomy Instrumentation
- Microwave Radiometry

APPLIED TECHNOLOGY, INC.
930 Industrial Avenue • Palo Alto, California

(Continued from page 86)

CORONA-FREE RESISTORS AVAILABLE FROM WESTINGHOUSE

High-voltage resistors for use with radar power supplies as a bleeder and sensing devices are now available from the Westinghouse Electric Corp., Pittsburgh, Pa.

The high-voltage resistor is a visual and audible corona-free voltage dropping unit. The various components are assembled to form a self-supporting, free-standing resistor. All parts are designed to eliminate any concentration of high-voltage stresses which may cause electrical interference. This is accomplished by isolating each module from each other and terminating the module circuit to the specially designed outer aluminum shields.

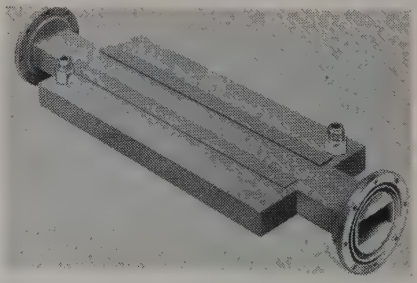
Modular design makes it possible to stack modules to conform with voltage requirements in a compact assembly. For example, 10 modules at 30,000 volts per module, when stacked, will operate at 300,000 volts.

Circle Reader Service Card 116

— *mwj* —

WAVEGUIDE DIRECTIONAL COUPLERS AVAILABLE FROM BOMAC

New Waveguide Directional Couplers introduced by Bomac Laboratories, Inc., Beverly, Mass., are offered in three general configurations: cross guide coupling, sidewall coupling, and topwall coupling to meet the requirements of moderate cost, high power handling capacity and high directivity, respectively.



The units are available with customer specified coupling value, with power handling capacities ranging from 70 - 2700 kw.

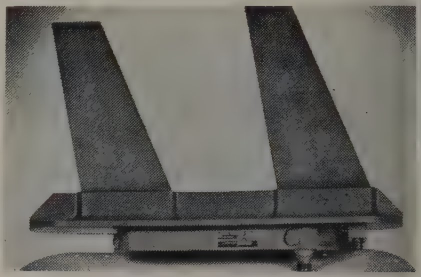
Circle Reader Service Card 117

— *mwj* —

DUAL PATTERN UHF ANTENNA DESIGNED BY TRANSCO

A new "dual pattern" UHF data link antenna, type 35500, has been designed by Transco Products, Inc., Los Angeles, Cal., for use on high performance jet aircraft.

The unit has dual radiation pattern coverage, controlled by a self contained coaxial switch in the power divider and phasing network. With the switch solenoid de-energized, the radiation pattern is essentially omni-directional in the azimuthal plane. In the energized position a cardioid shaped radiation pattern occurs, producing a front to back ratio of —17 db or greater over the frequency range 225 - 400 Mc. Polarization is vertical; VSWR is less than 2.5:1 in the omni pattern and less than 1.5:1 in the cardioid pattern.

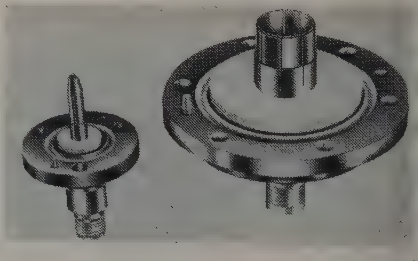


The self contained antenna, including radiating elements, power divider and phaser network, has passed qualification testing to Mil Spec.

Circle Reader Service Card 118

— *mwj* —

BOGART DEVELOPS SERIES OF COAXIAL TO COAXIAL TRANSITIONS



A new series of Coaxial to Coaxial Transitions, designed as compact lightweight devices for both systems and laboratory use, has been developed by Bogart Manufacturing Corp., Brooklyn, N. Y.

The models 6000-6001 feature short insertion length and low VSWR and provide a low cost transition from type N male or female to 7/8 inch, 1 5/8 inch and 3 1/8 inch coaxial lines. The units will shortly be available as "off-the-shelf" stock items.

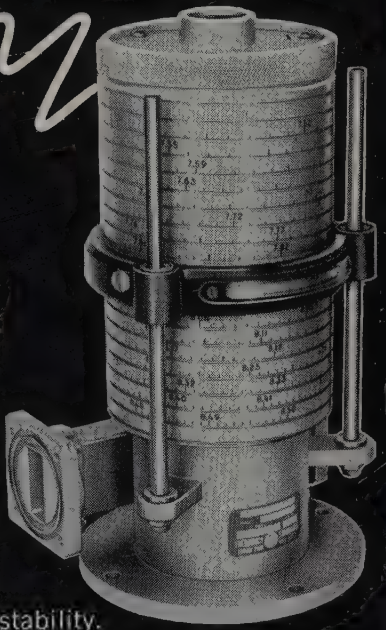
Circle Reader Service Card 119

— *mwj* —

(Continued on page 96)

Direct Reading Microwave Wavemeters

Proven in Performance and Reliability .01% Accuracy



Covering a frequency range of 500 mc to 18 gc with .01% maximum error, Frequency Standards' precision-engineered wavemeters combine greater accuracy of readout with a broader frequency range in both absorption and transmission types. Each unit provides direct readout **without chart** and is individually calibrated and temperature compensated for a high degree of accuracy and stability. Higher accuracies can be obtained depending on other limitations.

Frequency Standards, America's foremost center for new ideas in microwave technology, produces this precision wavemeter in absorption, termination, and RF transmission styles both for laboratory and operational applications. For outdoor use a direct reading model is furnished in a ruggedized waterproof carrying case. **Delivery within 10 days** • For information on the complete line of wavemeters, write for catalog P-26102.

Certified: All wavemeters are calibrated against standards originating with the U. S. National Bureau of Standards.

DEPT. KW

FREQUENCY STANDARDS

A DIVISION OF HARVARD INDUSTRIES, INC.
BOX 504 · ASBURY PARK, N. J. · PROSPECT 4-0500

Center for Microwave Components: Wavemeters • Reference Cavities • Signal Sources • High Power Filters • Discriminators • Antenna Couplers • Diplexers • Duplexers • Directional Couplers • Antennas • Cavities

Circle Reader Service Card 53

STREPITUM MINUERE

"To Restrain Noise". . . One of the tasks at ATI is that of developing low-noise broad-band preamplifiers per specific operational requirements. In reconnaissance and surveillance activities low-noise preamplifiers with octave, or greater, bandwidths are needed to augment ELINT (ELectronic INTelligence) Collection Systems. In supplying equipments meeting these requirements, ATI has produced a line of low-noise preamplifiers that span the VHF through the microwave frequency domain. Typical VHF preamplifiers have bandwidths exceeding three octaves with noise figures less than 6 db.

Another recent task involved the development of a miniature 160 Mc amplifier having a noise figure less than 3.5 db. This item is now in production.

Other development efforts involving classified techniques and devices are directed toward achieving greater bandwidths with lower noise figures while maintaining the objective of practical end item equipment to satisfy an operational requirement.

Interested engineers who desire to become part of a task-oriented organization where the individual participates "from concept to reality" are invited to submit their experience resumes to Dr. John L. Grigsby, Chief Engineer.

ATI

AREAS OF SPECIALIZATION:
- ELINT Receiving Systems
- Deceptive Electronic Countermeasures
- Broad-Band Amplification
- Ionosphere Research Instrumentation
- Radio Astronomy Instrumentation
- Microwave Radiometry

APPLIED TECHNOLOGY, INC.
930 Industrial Avenue • Palo Alto, California

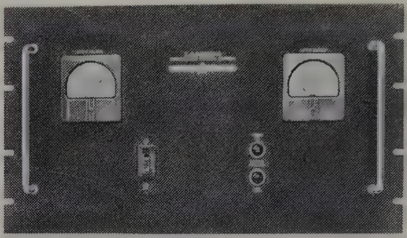
New Products

(Continued from page 94)

LAMBDA ADDS TO ITS POWER SUPPLIES SERIES

The addition of a new convection cooled 20 amp 0-34 VDC transistorized regulated power supply in a 10 1/2 inch panel height to the Lambda LA Series has been announced by Lambda Electronics Corp., Huntington, L. I., N. Y. Lambda has also improved specifications for its 5 and 10 amp models in the LA Series.

All of the LA Series models provide line regulation better than 0.05 per cent or 8 millivolts, whichever is greater, for input variations from 100-130 VAC. Load regulation is better than 0.10 per cent or 15 millivolts, whichever is greater, for load variations from zero to full load.



The units provide excellent transient response and impedance. Convection cooling eliminates blowers. Swing-open backs permit easy servicing in rack, and all major component terminals are accessible from the rear.

Circle Reader Service Card 120

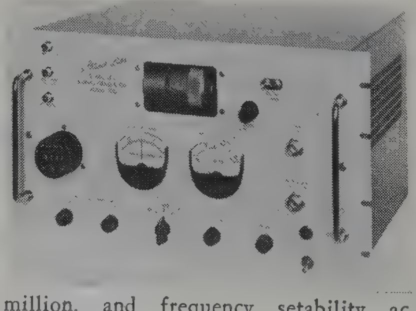
—*mwj*—

STRAND OFFERS OCTAVE-BANDWIDTH SIGNAL GENERATOR

A new "S" Band, three kMc, stabilized signal generator providing full-octave bandwidth is now available from Strand Labs, Inc., Newton, Mass.

Designated as model 800, the instrument is ideal for use as a prime signal source with varactors and other frequency multiplying systems, as well as for test and calibration wherever high RF stability is required.

The instrument's design incorporates a unique patented Microwave Discriminator and high-gain dc feedback amplifier providing automatic frequency control of the klystron oscillator to 0.01 parts per million, and frequency setability accuracy of 0.05 per cent.



Circle Reader Service Card 121

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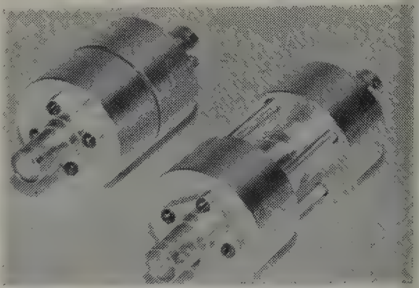
RADAR DESIGN OFFERS PRECISION COAXIAL ATTENUATOR



Radar Design Corp., Syracuse, N. Y., is offering a precision coaxial attenuator which uses standard cascade sections to give fixed attenuation up to 60 db.

The model #D-1362 has a maximum frequency sensitivity of .1 db/10 db over the 500-1000 Mc range. BNC Connectors are standard, but type N, TNC, or C are available to special order. Price is $110 each in small quantity, and delivery is three weeks.

Circle Reader Service Card 122

—*mwj*—

GENERAL MICROWAVE OFFERS TYPE 451 POWER METER

General Microwave Corp., Farmingdale, N. Y., announces its type 451 Microwave Power Meter, which is designed to operate with a wide variety of 100 and 200 ohm, positive or negative temperature coefficient bolometers.

Five scale ranges with full-scale readings of 0.1, 0.3, 1.0, 3.0, 10 mw are provided. Corresponding decibel scales are −10, −5, 0, +5 and +10 dbm. Higher power levels may be measured using auxilliary calibrated attenuators or directional couplers.

Frequency range is dependent only on the external detector; bias current to 16 milliamps is provided; and accuracy is held to within ±5 per cent of full scale reading.

Circle Reader Service Card 123

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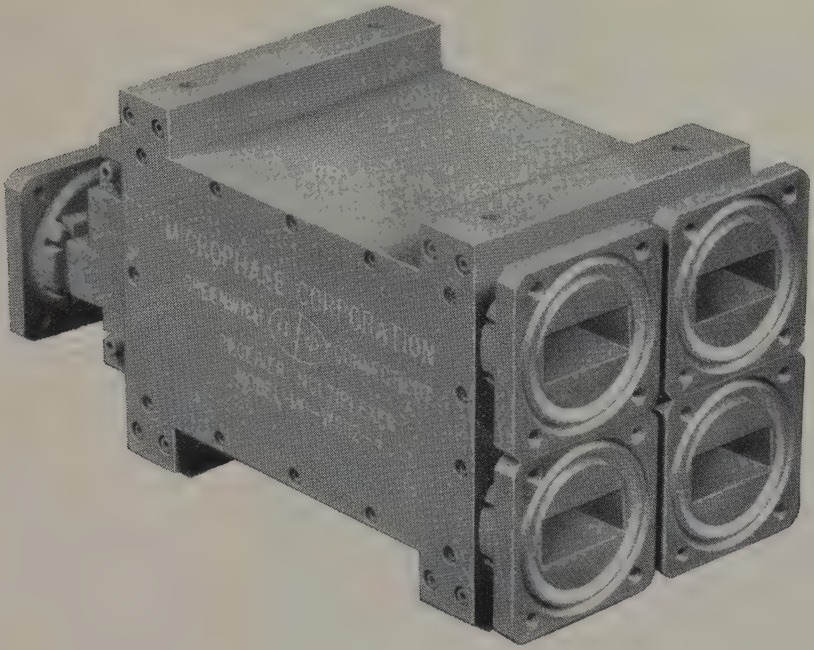
(Continued on page 98)

MC Waveguide Multiplexers



MICROPHASE PART NUMBER
MP-WG112-4

X-Band Waveguide Quadruplexer connects four receiver channels to a common antenna. The channel spacing is less than 200 mc, yet a high degree of isolation between channels is provided.

The unit is rugged and compact, with outline dimensions of 3⅞″ x 4″ x 8⅞″ and a weight not exceeding four pounds. It is equipped with UG-52A/U flanges at both antenna and receiver terminals. It is designed to withstand satellite-launch shock and vibration.

PERFORMANCE CHARACTERISTICS

Channel Bandwidth (3 db)	50 mc approx.
Insertion Loss	1 db max. (over 30 mc)
Passband Flatness	±0.1 db (over 30 mc)
VSWR (both input and output terminals)	1.5 max. (over 30 mc)
Isolation (channel-to-channel)	50 db min.
Sideband Suppression	40 db min.
Phase Response	Linear over 30-mc Bandwidth

Microphase will design and manufacture Waveguide Multiplexers to your requirements. Send inquiries to Microphase Corporation, Section RD-2, River Road, Cos Cob, Connecticut.

MICROPHASE
CORPORATION

Box 1166W Greenwich, Conn. NO 1-6200 WE 9-9190 TWX GNWICH CONN 759

Circle Reader Service Card 55

BACKSCATTER

BACKSCATTER

BACKSCATTER

BACKSCATTER

You'll be interested, if your field involves the study of ionospheric variations, in the ATI *Backscatter Sounders*. ATI sounders are basically radar-like instruments and generally operate in the HF and VHF regions at peak power levels of several kilowatts.

Applied Technology, Inc. has developed inexpensive specialized backscatter sounding equipment in the range 10 to 54 Mc with peak output power levels in excess of 20 kilowatts. Echoes to ranges in excess of 10,000 kilometers are usually obtained. Swept frequency operation provides considerable versatility and allows the evaluation of irregularities within the ionosphere as a function of frequency and time.

Our presently developed sounding equipment may be useful for your requirements. If not, our staff is available to design and produce new systems according to your particular operational situation. Ionosphere Instrumentation is another of the development areas in which the ATI "Concept to Reality" philosophy has resulted in superior equipment meeting strict performance specifications.

Engineers who want to become part of a task-oriented organization where the individual participates "from Concept to Reality" are invited to submit resumes to Dr. John L. Grigsby, Chief Engineer. Employee stock participation is available.

ATI

AREAS OF SPECIALIZATION:
- ELINT Receiving Systems
- Deceptive Electronic Countermeasures
- Broad-Band Amplification
- Ionosphere Research Instrumentation
- Radio Astronomy Instrumentation
- Microwave Radiometry

APPLIED TECHNOLOGY, INC.
930 Industrial Avenue • Palo Alto, California

Circle Reader Service Card 56

(Continued from page 96)

DC NULL VOLTMETER HAS HIGH INPUT IMPEDANCE

Outstanding stability and resolution with one mv end scale sensitivity, and a floating, high-impedance input are principal features of the new DC Null Voltmeter, by Hewlett-Packard Co., Palo Alto, Cal.

The model 413A has 13 zero-centered ranges, running from one mv to 1000 volts end scale. High input impedance (10 megohms on the most sensitive range, 200 megohms on the 300 mv range and above) makes this instrument especially valuable in resistance bridge measurements. The input terminals are isolated from ground, allowing operation up to 500 volts dc or 130 volts ac from ground potential. Accuracy of the model 413A is within 2 per cent of end scale. Drift and noise are virtually imperceptible.

Because the dc null voltmeter provides an output proportional to meter deflection, it is an exceptionally stable dc amplifier. For this use, the high voltage gain, high stability and low noise of the model 413A make it particularly suitable in many control applications, especially where the amplifier must be left unattended for long periods of time.

Circle Reader Service Card 124

— *m w j* —

CRYOGENIC THERMOMETER BUILT BY MALAKER

The first completely integrated electronic cryogenic thermometer has been introduced by Malaker Laboratories, Inc., Mountainside, N. J.

Called the "Cryotherm," the unit measures temperatures in the range of 0.3°K to 25°K. Measurements can be made readily without need for any special compensation and read directly on a calibrated scale to extreme accuracies.

The unit is provided with probes designed to fit conveniently into test Dewars. The probes measure mutual inductances as small as 2 x 10-4 micro-henries using an ac bridge circuit and utilize ruby crystals to provide high precision measurement at this low temperature range.

The Cryotherm operates from an ac bridge current supplied by a modula plug-in signal generator tuned to 15 cycles. The output from the bridge is amplified by a high sensitivity, low noise transistorized amplifier having both narrow band and noise filters.

Circle Reader Service Card 125

— *m w j* —

TELEMETRY RECEIVER CONSTRUCTED BY VITRO

A pre-detection telemetry receiver ha been added to the line of Nems-Clark telemetry equipment produced by Vitr Electronics, Silver Spring, Md.

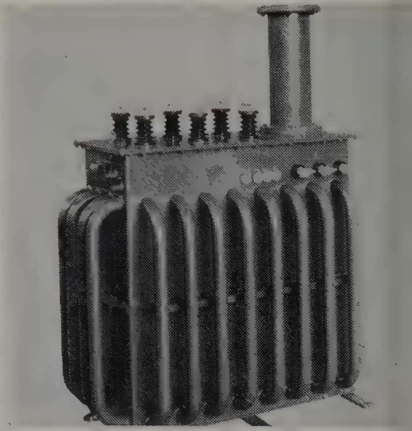
The receiver, known as the type 145 pre-detection telemetry receiver, provide a means of collecting telemetry data prio to demodulation when used together wit the Nems-Clarke pre-detection converte type IFC-1400, and a magnetic tape recorder having a one Mc or higher frequency response.

The type 1450 receiver operates in th 215 to 260 Mc telemetry band and is fitte with connectors for recorder output an playback input. Switching from one function to the other is accomplished from th front panel, permitting the operator t record or to play back for demodulatio of recorded signals.

Circle Reader Service Card 126

— *m w j* —

POWER SUPPLY DELIVERS 30 KV DC AT 2.5 AMPS



An insulated self-cooled power suppl capable of delivering 30 kv dc at 2. amperes has been designed and is bein manufactured by Hill Magnetic Product Menlo Park, Cal.

Hill Magnetic Products manufacture transformers, reactors, power supplie and associated components for powe pulse, audio, and Hi-Energy system Units are designed and custom-built t customer specifications.

Circle Reader Service Card 127

— *m w j* —

(Continued on page 100)

A rose by any other name . . . etc., etc., etc. Shakespeare, we finally realized, was right. In the depths of the night quite recently, we recalled, with not a modicum of horror, those first disastrous days when we were trying to put a name to the corporation now known as Rantec. "It's gotta have 'micro' in it," an officer high on the echelon (there were three of us at the time) claimed, "without 'micro' we just ain't in the electronics business." "Well, we're not, really," some wretched iconoclast put forth, "has anybody seen a contract around here yet?"

Having gotten rid of *him*, we settled down to facts, or some semblance thereof. R for radomes, ANT for antennas, EC for electronic components. RANTEC. Fabulous. Meaningful. Easy to say with your mouth full. And it was truly valid for about three and a half days. Although we still make antennas (and quite a number, if the truth be known), Rantec is now involved up to its neck in ferrite devices, multiplexers, waveguide components and microwave sub-systems. See what we mean.

The upshot of this entire thing has been a little game called "Pin the Tail on the Electronic Firm" which has succeeded in pulling our senior research engineers away from the ping pong table and our technicians away from the chessboard. The amazing thing is that the game has no prizes and nobody wins. Of course, nobody loses either which might or might not mean something. The rules are simple: name a fictional electronic firm. Although, as we said, there are no prizes, no one can deny us the right of picking our favorites. Try these on for size. (1) HydroPeptic, manufacturers of irrigation equipment; (2) Macroneurotic and its wholly-owned subsidiary, Frustronics, which provide problems instead of solutions; and (3) Myoptics, Inc. which designs and develops complete systems with equally complete obsolescence.

If first prize there were to be, it must be awarded to one of our brilliant electronic engineers who thought it might be wise to open up a second-hand hardware company in Culver City, California, and call it the Used Tool Company.

Any engineer on the outside who might have a smattering of knowledge about microwave theory or antennas or electronics of various orders and who might or might not want a job can join in the fun. Send your answer to Rantec Corporation, Calabasas, California. Rantec. That's pretty funny, right there.

it's what's up front that counts

Speaking of filters, Rantec is way up front. Men who know filters best in such projects as Mercury, Titan, Polaris and Discoverer—choose Rantec two to one. Why? Strictly the result of Rantec's superb miracle blend of research and development.

Broadband Harmonic Filters from C through K, bands rejecting the second and third harmonics of any frequency in the pass-band region . . . **Waveguide Band-Pass Filters** employing from one to fifteen cavities with precise equal-ripple, maximally flat insertion loss or maximally flat time-delay response . . . **Coupled Coaxial Resonator and Coaxial Low-Pass, High-Pass and Band-Pass Filters** in frequency ranges from 100mc to 10,000mc . . . **Stripline Diplexing Filters** to meet specific customer specifications for packaging, frequency band, response, isolation and power rating.

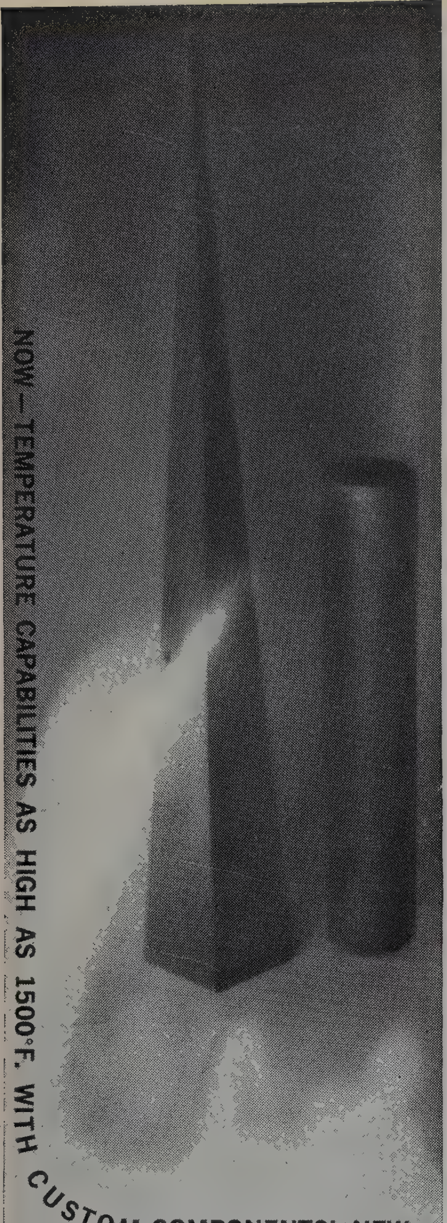
Below . . . the FS-203 Band-Pass Filter—pass-band 2,000-4,000mc; stop-bands 0-1,800mc, 4,400-12,000mc; VSWR in pass-band 1.5 max.; insertion loss 1db max. in pass-band, 50db min. in stop bands; impedance 50 ohms.

Reach for a Rantec . . . available in crush proof and soft pack! Also from Rantec . . . antennas, ferrite devices, waveguide components, electric components and microwave sub-systems.

r a n t e c

Rantec Corporation • Calabasas, California

Circle Reader Service Card 57



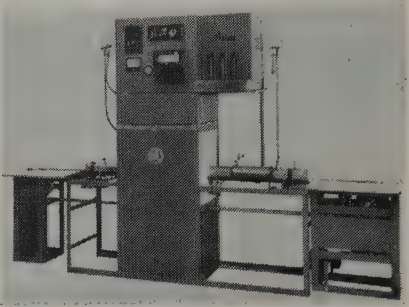
NOW—TEMPERATURE CAPABILITIES AS HIGH AS 1500°F. WITH CUSTOM COMPONENTS' NEW PERMEABLE DIELECTRIC, CMA-701, WHICH MAINTAINS ITS PHYSICAL PROPERTIES THROUGH 1500°F. USE IT FOR TERMINATIONS, ATTENUATORS, RF GASKETS, ETC.—WHEREVER A MICROWAVE ABSORBER MUST FUNCTION IN A HIGH TEMPERATURE ENVIRONMENT. OUR DESIGN, TEST AND PRODUCTION FACILITIES ASSURE PREMIUM PERFORMANCE. CONSULT

CUSTOM COMPONENTS, inc.

P.O. Box 248, Caldwell, N.J.
CApital 6-3404

(Continued from page 98)

ATMOSPHERE FURNACE FOR CONTINUOUS SOLDERING DEVELOPED BY BTU



BTU Engineering Corp., Waltham, Mass., has developed a standard, controlled atmosphere furnace which permits continuous Flux-Free soldering or brazing, yielding uniform high quality and high volume at greatly reduced cost. Created originally for special requirements of the semiconductor industry and incorporated into automated production lines, this type furnace, designated Transheat Model TS-1X18, is now available for general use in the electronics or allied industries. Standard working chamber size is 2 inches wide x 2 inches high.

Fluxless soldering under controlled hydrogen atmosphere eliminates the disadvantages of handling flux and produces a clean oxide free bond with excellent wetting characteristics that far exceed those produced with flux.

The gas control system of the furnace, which is a BTU Engineering Corp. development, offers complete safety and fail safe provisions for the handling of hydrogen. Purity of the atmosphere within the furnace can be maintained to less than one part per one million.

Circle Reader Service Card 128

—mwj—

ANTENNA CALCULATOR PRODUCED

A parabolic antenna calculator announced by the Technical Appliance Corp., Sherburne, N. Y., determines quickly and accurately performance data on parabolics.

The TACO calculator covers all of the information usually required to determine gain beamwidth, etc. for estimates and final system design.

Data given includes: wavelength in inches or centimeters; beam width relative

(Continued on page 102)

NEW moderately priced high-precision SLOTTED LINES

- Rated residual VSWR under 1.010; rated error in detected signal under 1.005.

An AMCI Type 2181 Slotted Line with interchangeable precision tapered-reducers provides for accurate measurements in several transmission line sizes from Type BNC to 1⅝" or larger. An untuned rf probe is supplied as part of the slotted line. Several tunable detector probes are available as optional accessories.

Write for complete information on AMCI Slotted Lines.

Type	Frequency range	Slot length	Pric
2181-2	300 to 4000 mc	20 inches	$7
2181-3	200 to 4000 mc	30 inches	$75
2181-4	150 to 4000 mc	40 inches	$8
2181-6	100 to 4000 mc	60 inches	$92

*including an input adapter to Type N and an untuned rf probe but exclu ing output tapered reducers and tunable probes. Prices are F.O.B. Bost Mass., and are subject to change without notice.

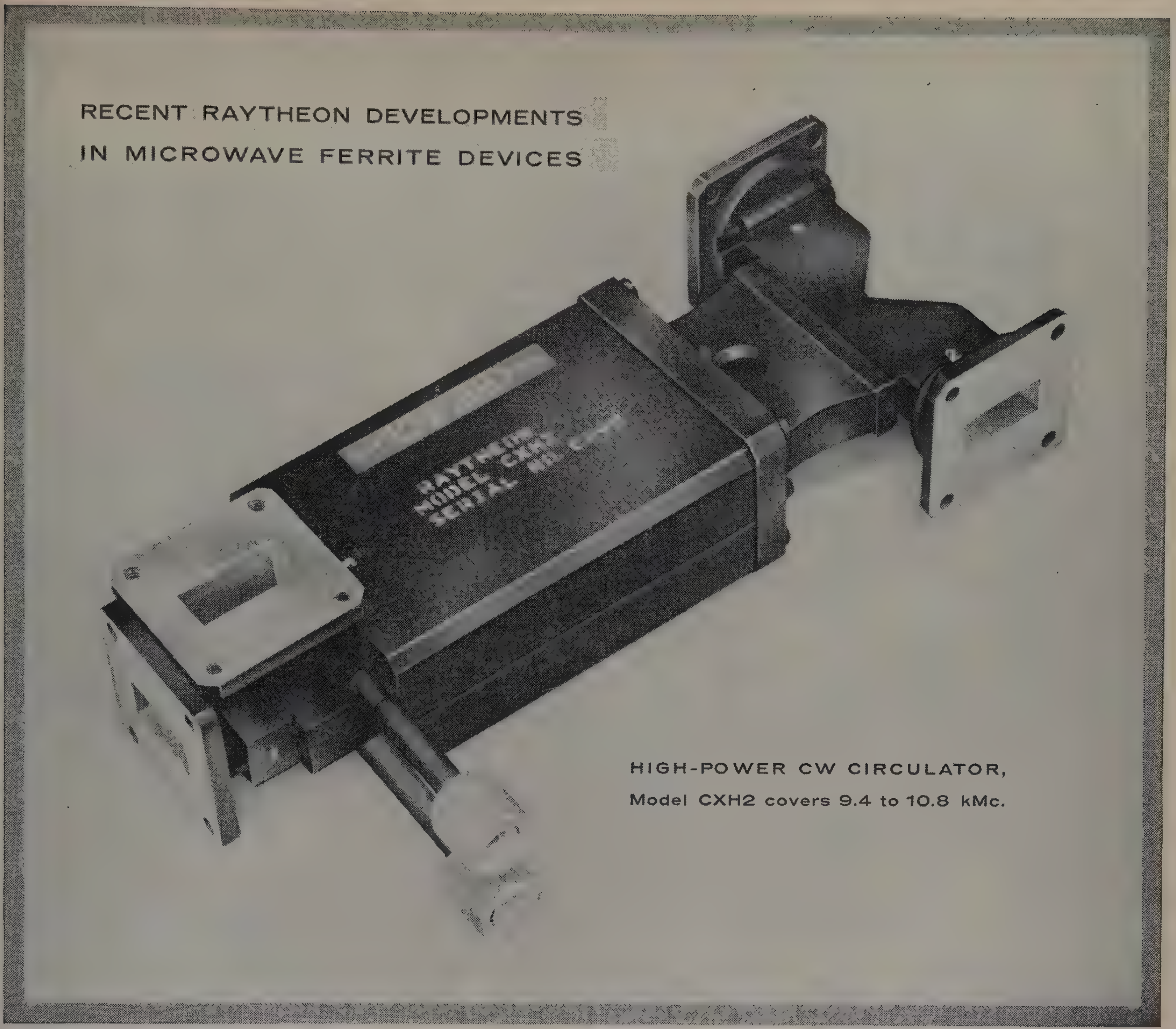
AMCI ANTENNA SYSTEMS — COMPONENTS — AIR NAVIGATION AIDS — INSTRUMENT

ALFORD *Manufacturing Compan*
299 ATLANTIC AVE., BOSTON, MASS

Circle Reader Service Card 59

Circle Reader Service Card 58

RECENT RAYTHEON DEVELOPMENTS
IN MICROWAVE FERRITE DEVICES



HIGH-POWER CW CIRCULATOR,
Model CXH2 covers 9.4 to 10.8 kMc.

Versatile X-band circulators handle cw power in excess of 10kW

New high-power ferrite device provides over 20 db isolation; can be used as isolator with suitable auxiliary loads.

An advanced line of Raytheon high-power circulators keeps abreast of new X-band tube developments.

Typical of these compact units is the CXH2 covering 9.4 to 10.8 kMc with a continuous power rating of 10kW. Isolation is 20 db minimum, insertion loss is 0.2 db maximum and VSWR is 1.15 maximum.

Used as an isolator—in conjunction with suitable auxiliary loads—the CXH2 will handle continuous power levels to 10 kilowatts with a back-to-front ratio greater than 100:1. Similar units are available for use at high peak power levels.

For complete details on this and other significant developments in high-power microwave ferrite devices, please write to Special Microwave Devices Operation, Raytheon Company, Waltham Industrial Park, Waltham 54, Massachusetts.

TYPICAL SPECIFICATIONS • MODEL CXH2

Frequency	9.4—10.8 kMc
Power	10kW (cw)
Isolation	20 db min.
Insertion loss	0.2 db max.
VSWR	1.15 max.
Length	9 3/16 in.
Flanges	UG 39/U
Waveguide	RG 52/U
Weight	Less than 4 lbs.
Water cooled	0.75 gpm.

RAYTHEON

RAYTHEON COMPANY

SPECIAL MICROWAVE DEVICES OPERATION

one stands out

Superiority of design, manufacture and performance are never an accident. Quality must be planned!

When you next specify **Coaxial Connectors,** specify . . .

Automatic
METAL PRODUCTS CORPORATION
323 Berry St., B'klyn 11, N. Y. • EVergreen 8-6057

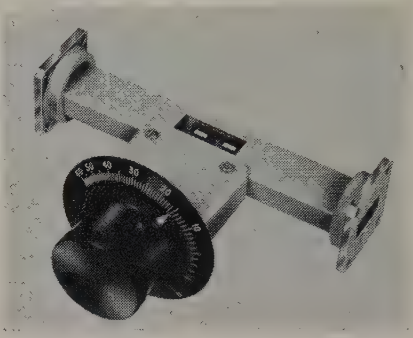
(Continued from page 100)

to frequency and parabolic reflector diameter; db gain at given efficiency; free space attenuation at required frequency and range; subtended angle at given F/D; return loss and mismatch loss vs. VSWR; and force, (in pounds) transferred to the mounting structure for solid and expanded metal antenna diameters at wind velocities from five to 200 MPH.

Circle Reader Service Card 129

— m w j —

WEATHERPROOF VARIABLE ATTENUATOR AVAILABLE FROM GENERAL MICROWAVE



Ideally suited for military flight-line and ground-support equipment applications, the Type 170 Series of panel-mounting attenuators from the General Microwave Corp., Farmingdale, N. Y., are available in most waveguide sizes. The attenuators can alternately be furnished for operation over full waveguide bandwidth or with direct-reading calibrated dials for narrower-band use.

Features of the instrument include a drip-proof dial as a precaution against effects of rain and humidity and a metallized ceramic element for rugged shockproof field performance.

Circle Reader Service Card 130

— m w j —

RAYTHEON INTRODUCES RUGGED Ka-BAND KLYSTRON

A rugged Ka-band klystron for local oscillator-transmitter service in aerospace applications has been introduced by Raytheon Company's Microwave & Power Tube Division, Waltham, Mass. The QKK834 utilizes a sapphire rod fo smooth wide-range tunability from 34 35.6 kMc and can be electronically tune over any 110 Mc portion of its range.

Compact all metal and ceramic construction makes the QKK834 extremely rugged with excellent thermal stability The tube requires a resonator voltage o only 400 volts and has a minimum powe output of 10 mw. For flexibility i mounting, the dielectric tuner mechanism may be located anywhere on the circumference of the resonator at least 90° from the output. RF output is through a standard waveguide flange, sealed by a ceramic window.

A companion tube, the QKK923, cover the K-band range from 23.5 - 24.5 kMc Price of both tubes is $1600, with availability 90 days from receipt of order.

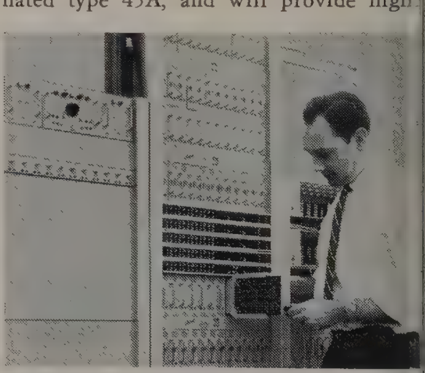
Circle Reader Service Card 131

— m w j —

600 CHANNEL MULTIPLEXING SYSTEM AVAILABLE FROM LENKURT

Lenkurt Electric Co., Inc., San Carlos Cal., is offering a 600 channel multiplexing system for long-haul use on microwave radio.

The new transistorized system is designated type 45A, and will provide high



grade voice circuits on as many as seve tandem links totaling up to 4000 miles i length. It coordinates on an end-to-en basis with Western Electric type "L" multiplexing equipment.

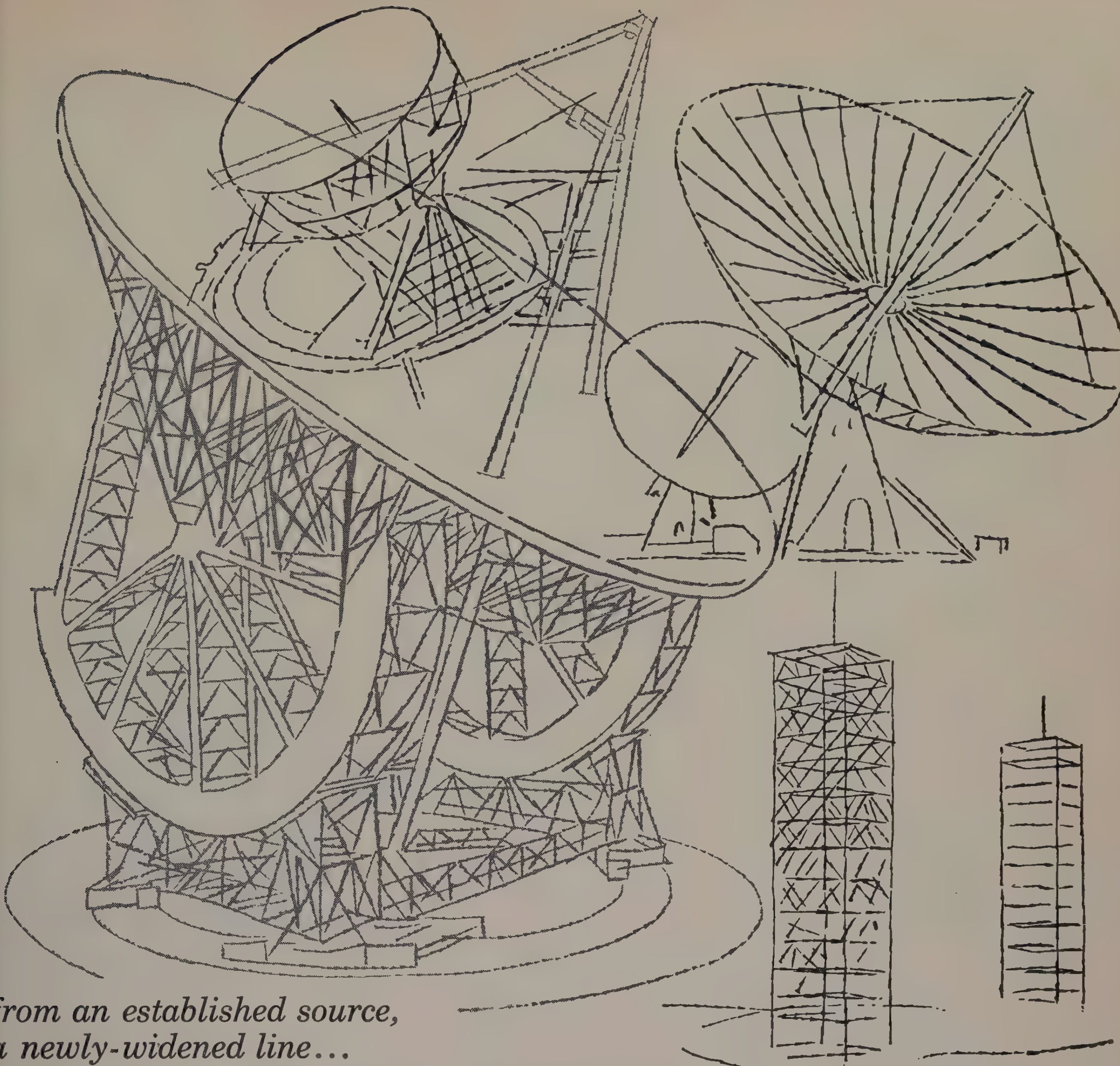
With full 600 channel system loading type 46A's power-handling capability i more than twice as great as that recommended by the International Consultativ Committee on Telegraphy and Telephony (CCITT).

Total per-channel noise and crosstal for a single link will not exceed 23 db. more than one per cent of the busy hou with system loading of 75 per cent voic and signaling, 17 per cent telegraph, an 8 per cent SAGE data.

Circle Reader Service Card 132

— m w j —

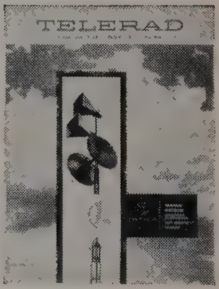
(Continued on page 104)



from an established source,
a newly-widened line...

TELERAD R-F Systems, Instruments, and Components

At Telerad Division of The Lionel Corporation, we are continually broadening our line of products and services in r-f communications. We offer complete transmission systems, a full line of waveguide and coaxial components, and custom-engineered instrumentation on request. Telerad has long held an excellent reputation for precision products, manufactured to the most demanding industrial and MIL specifications. The Telerad/Lionel force gives an ever increased capability in the field of r-f communications, both in an expanded line of hardware and in special orders for systems constructed to your specifications.—▪—A few of the instruments and components available from Telerad include: power supplies, signal generators, antennas, feeds and horns, missile radar beacons, mixers, duplexers, directional couplers, rotary joints, filters, attenuators, wavemeters, frequency meters, fixed and flexible waveguides, and many other products.—▪—For an established source of radio-frequency systems or components, contact:



Send for new expanded line product catalog.

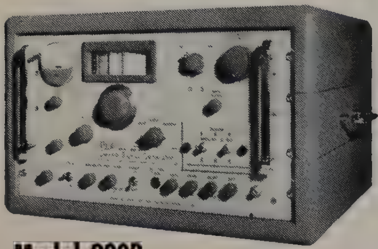
Telerad Division
THE LIONEL CORPORATION
Route 69-202, Flemington, New Jersey

Circle Reader Service Card 62

JERROLD®

SWEEP GENERATORS

NEW!



Model 900B

Very narrow to very wide sweep widths in one sweep SIGNAL generator

$1880.00

Unusual stability in sweep widths from 10 kc to 400 mc. Frequency range 500 kc to 1200 mc. Built-in crystal-controlled harmonic markers, direct coupled scope pre-amplifier, and attenuators. The ultimate instrument for your IF-VHF-UHF requirements.

Model 900A

Wide-band sweep generator

$1260.00

Center frequency: VHF, 0.5 to 400 mc; UHF, 275 to 1000 mc. Sweep widths from 100 kc up to 400 mc. Flatness: ±0.5 db over widest sweep.

Model 707

Ultra-flat sweep generator

$795.00

Featuring ±5/100 db flatness; plug-in oscillator heads*; variable sweep rates from 1/min. to 60/sec.; all electronic sweep fundamental frequencies; sweep width min. of 1% to 120% of C.F.

*Heads available within the spectrum 2 to 265 mc. Narrow-band heads on request.

For applications bulletin and complete catalog (including wide-band comparators, precision attenuators and accessories), write:

JERROLD® ELECTRONICS CORPORATION
Industrial Products Division, Dept. ITE-99
The Jerrold Building, Philadelphia 32, Pa.

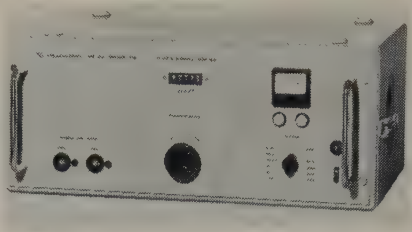
Jerrold Electronics (Canada) Ltd., Toronto
Export Representative: Rocke International, N. Y. 16, N. Y.

Circle Reader Service Card 63

New Products

(Continued from page 102)

FREQUENCY STANDARD DRIFT REDUCED



Rohde and Schwarz Sales Co., Inc., Passaic, N. J., announces an improved version of its Type XSA Frequency Standard, with guaranteed frequency drift below 5 x 10^{-10}/day after 30 days of operation. The spring suspended, double-walled oven used in the XSA provides crystal protection from physical and thermal shock. The resulting elimination of external influences tends to provide increasing stability with continued operation.

The XSA is designed for manual, remote control with built-in ac synchro receiver, or automatic adjustment in which case a separate receiver and phase comparator is required. The range of adjustment is 2 x 10^{-6} and indication is provided by digital counter in units of 1 x 10^{-10}.

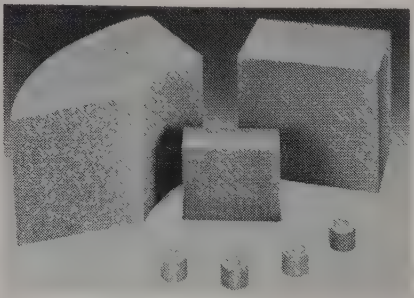
Output frequencies are one Mc and 100 kc at one volt levels, available from the front panel with an auxiliary 100 kc output plug on the rear of the cabinet. Spurious modulation of the output is held to below 80 db in the improved model.

Circle Reader Service Card 133

—*mwj*—

ARTIFICIAL DIELECTRIC MATERIAL MADE OF POLYURETHANE

PolyStructures, Inc., Stoneham, Mass., now has the capability for producing rigid polyurethane foam with ferrous or non-ferrous mixture in such a way that the finished plastic will have closely controllable and predetermined dielectric properties.



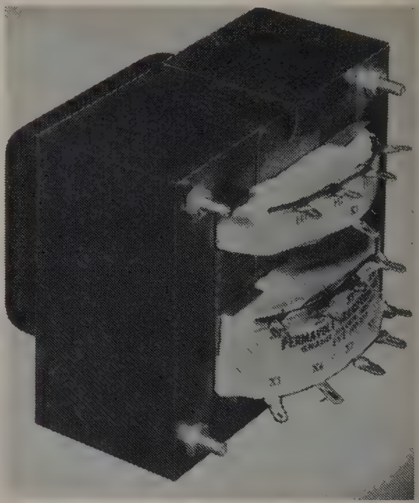
The rigid foam plastic can have a dielectric constant ranging from 1.2 - 3.0, and its density can be varied from two to 25 pounds per cubic foot. With these characteristics, the new material is well suited for microwave components such as reflectors, lenses, attenuators, absorbers, dopplers, antennas, and parabolic dishes. Components made of this material offer the following advantages: high strength-to-weight ratio; lightweight and simple to install; long lasting and not affected by normal ambient temperatures, humidity, and salt water. Individual parts can be reinforced with other types of plastic for greater structural strength.

PolyStructures, Inc., designs, manufactures, and tests plastic products for applications in the microwave field.

Circle Reader Service Card 134

—*mwj*—

PERMAVOLT ANNOUNCES CONSTANT VOLTAGE TRANSFORMER



A new constant voltage transformer has been announced by Permavolt Transformers, Inc., Grand Haven, Mich. The Permavolt transformer is recommended for close control of filament, plate and transistor voltages.

When used in dc power supply applications, the new design offers the advantage of reduced filtering cost and size. Output voltage tolerances for input line variations of ±15 per cent are ±3 per cent for standard models. Output tolerances of as low as ±1/2 of one per cent can be supplied in custom design. The output current is limited and can be designed to-protect the circuit it is feeding against short circuits.

Permavolt transformers can be custom designed for practically any application up to 15 kva. Multiple input and output windings are available in the same combinations as conventional transformers. Permavolt transformers also can be supplied in any type of enclosure.

Circle Reader Service Card 135

—*mwj*—

(Continued on page 106)

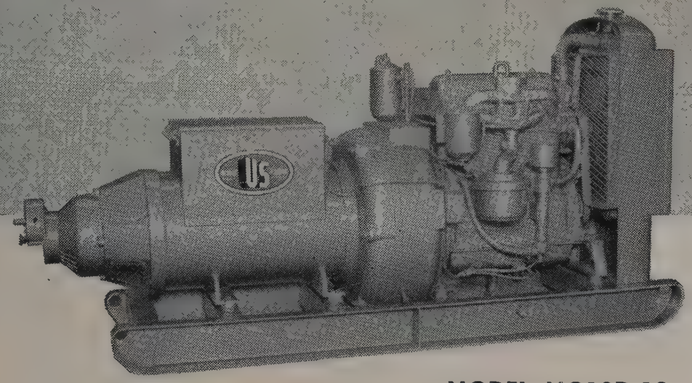
POWER SURETY

OF THE

COMMUNICATIONS INDUSTRY......

10 KW DIESEL MICRO POWER

WITH NEW "BRUSHLESS" GENERATOR



MODEL MG10D-18

"NO-BREAK" MICRO POWER ENERGY IS USED . . .

- at telephone central offices—carrier repeater stations.
- on Microwave installations for communications, remote control, telemetering.
- by public utilities for protective relaying, telemetering and load distribution.

U.S. MOTORS 10 KW DIESEL MICRO POWER functions either as a voltage stabilizer when power from the normal source is at usable, but uneven value — or as the independent power supply when there is a complete power failure. Regardless of the situation, critical communications equipment is assured a constant source of stable voltage electric power at all times. Micro Power, smoothly and with no break in required voltage, transfers the load back when commercial power is restored, at the same time continuing in its full time role of eliminating voltage droop, drop, or break.

10 KW DIESEL MICRO POWER FEATURES —

- no brushes, commutator, or slip rings to service or replace with new brushless generator
- squirrel cage motor with less than one percent slip
- conservatively rated bearings
- diodes arranged for easy access
- voltage adjusting potentiometer
- magnetic amplifier regulator mounted directly on unit
- overvoltage protection

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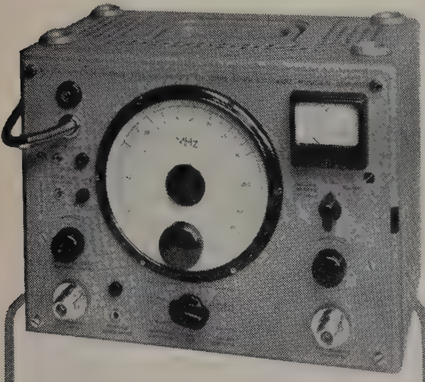
UNITED STATES MOTORS CORPORATION
102 West Fifth Avenue • Oshkosh, Wisconsin

FIFTEEN
IN
ONE
TUNABLE
VHF AMPLIFIER
TYPE ASV
30 to 300 MC



A Measuring Instrument That Functions as:

- Receiver
- Frequency Meter
- Voltage Amplifier
- AM Modulator
- Indicating Amplifier
- Null Detector
- AM Demodulator
- FM Demodulator
- Power Amplifier
- VHF Signal Generator
- Buffer Amplifier
- Limiting Amplifier
- 1000-cps Generator
- Frequency Converter
- Harmonic Generator

Here is an ideal combination of fifteen instruments all in one. Its numerous applications, compactness and accuracy make it a basic tool in the VHF range. Combined with other VHF equipment, the Type ASV will extend their measuring ranges and possibilities. Because of its high versatility, the use of one or more of these Tunable VHF Amplifiers will be found highly effective in solving measuring problems at low cost.

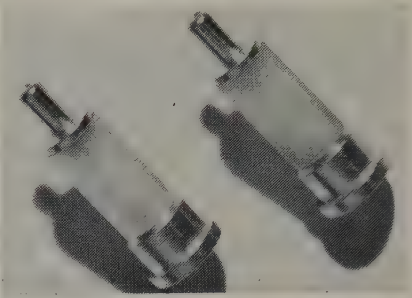
WRITE FOR ADDITIONAL INFORMATION

ROHDE &
SCHWARZ
111 Lexington Ave., Passaic, N. J.
PRescott 3-8010

New Products

(Continued from page 104)

MICROWAVE SEMICONDUCTOR OFFERS HIGH EFFICIENCY BOLOMETERS



A new line of high efficiency bolometers for absolute and relative microwave power measurements by Microwave Semiconductor & Instruments, Inc., Richmond Hill, N. Y., incorporates the latest 1N23 crystal diode cartridge design.

The bolometer elements are mounted between gold plated contacts within low loss dielectric housings achieving near theoretical maximum efficiency. The gold plated contacts, instead of coin silver, are non-tarnishing and corrosion resistant; units are hermetically sealed. The bolometers are rated at 200 ohms or 100 ohms at 8.75 or 4.5 ma and are capable of measurements at frequencies up to 18 kMc. The construction and design of this line of bolometers gives square law response errors of less than one per cent up to 0.2 mw.

Circle Reader Service Card 136

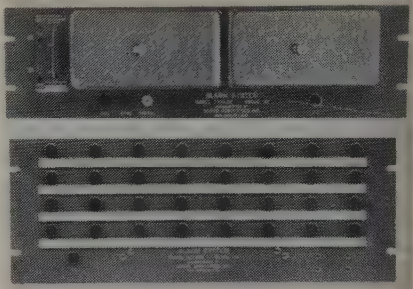
—*mwj*—

MOORE DEVELOPS MICROWAVE FAULT ALARM PACKAGE

Development of a microwave fault alarm system, providing immediate supervisory information of all monitored events, has been announced by James B. Bullock, vice president of Moore Associates, Inc., San Carlos, Cal.

Known as the Marc Solid State Microwave Fault Alarm Package, the system was developed for use in industrial and military communications systems. It features a continuous transmission of the status of all monitored events, whether or not alarms are present.

The Marc fault alarm system consists of unattended microwave repeater station terminals which incorporate a time-division-multiplex coder capable of transmitting up to 128 on-off alarm inputs, and a narrow-band frequency shift tone transmitter.



Circle Reader Service Card 137

—*mwj*—

NEW BOOKS

ANTENNA ENGINEERING HANDBOOK, Henry Jasik, Editor-in-Chief. Prepared by a staff of specialists. 1,040 pages; 6x9; illustrated; McGraw-Hill Handbook Series; $22.00.

This book covers in practical fashion the broad field of antenna engineering, including such new developments as frequency-independent antennas and surface wave antennas. The book is intended to provide a readily accessible source of basic information for the antenna design specialist, and it will be of wide interest to all electronics engineers and systems engineers who are concerned with antenna applications.

The handbook—composed of 35 chapters divided into the following broad divisions: basic antenna types, methods, applications, related engineering and technical information—represents the first time that a large amount of practical engineering information on the antenna field has been gathered between the pages of a single book. Each chapter is written by an expert in his particular field and includes, among other types, material on long wire, slot, loop, helical, horn, reflector, and scanning antennas. The engineering applications of receiving, transmitting, radar, air-craft, VHF and UHF communications antennas are also covered.

In step with recent advances in the field, the author includes material on large reflector-type antennas, surface wave antennas, scanning antennas, and radio telescope antennas. Special topics such as transmission lines, impedance matching and broadbanding, radome problems, propagation problems, and measurement problems are also covered.

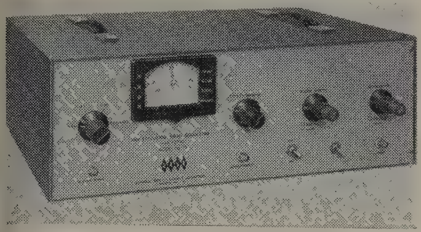
Henry Jasik, the Editor-in-Chief, is considered one of the leading antenna engineers and designers in the country, and is head of a laboratory devoted primarily to antenna research and development—Jasik Laboratories, Inc., Westbury, L. I., N. Y. Dr. Jasik is a Fellow of the Institute of Radio Engineers and served as past Chairman of its technical committee on Antennas and Waveguides. He is an editorial associate on *the microwave journal*.

—*mwj*—

GENERATOR FEATURES HIGH REPETITION RATES, NARROW PULSES

The General Applied Science Laboratories, Inc., Westbury, N. Y., announces the PG-10, a new pulse generator for use where high repetition rates and narrow pulses are required.

Specifications are: frequency range — 1-20 mcps in three overlapping ranges; accuracy — 3 per cent of dial setting; output — positive or negative. The unit weighs 60 pounds and measures 17 inches x 17 inches x 7 inches. Price is $1250, with delivery from 90-120 days.



Circle Reader Service Card 138

— *m w j* —

TRAVELING-WAVE TUBE PRODUCED BY GE

A lightweight, compact, low-noise traveling-wave tube with periodic permanent-magnet focusing is available from General Electric's Power Tube Department, Palo Alto, Cal., for operation in the 7,000-to-11,000 megacycle frequency range.

The tube, type Z-3088, was developed by the department's Traveling-Wave Tube Product Section and is especially suited for use as an input tube in airborne radar receivers and as a power amplifier in cascade chains. Other applications are in electronic counter-measures, microwave relay systems, radiometry and radar mapping, radio telescopes, drones and signal sources.

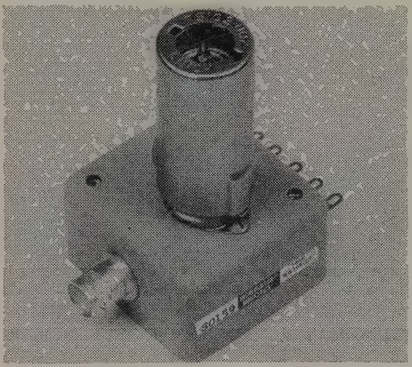
The Z-3088 has a noise figure less than 15 db, with a minimum gain of 35 db, and minimum power output of 5 milliwatts over its designed frequency range.

Circle Reader Service Card 139

— *m w j* —

SIGNAL SOURCES FOR 10 KC-400 MC NOW AVAILABLE

A new series of electronically tuned signal sources for use in the 10 kc - 400 Mc frequency spectrum is now available from the Increductor Magnetics Department of Trak Electronics Co., Inc., Wilton, Conn.



These packaged units, called the SO series, are a useful component for the RF engineer interested in sweeping applications. They produce a signal whose frequency is controlled by applying either a current or voltage, thereby eliminating the manual tuning requirement of conventional units.

In a typical vacuum-tube, single-band unit a change in frequency of 5 to 1 is produced by applying a control current between 0 and 70 milliamperes over the 10 kc - 200 Mc range. A 2 to 1 tuning ratio is available from 160 - 320 Mc and a 1.5 to 1 tuning ratio in the 180 - 400 Mc range.

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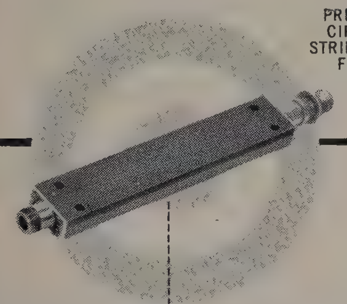
— *m w j* —

SUBMINIATURE DIODE COVERS 1-4,000 MC

An improved subminiature glass case low noise mixer diode for applications in the one Mc to 4,000 Mc region has been introduced by Microwave Associates, Burlington, Mass.

The 1N831A exhibits a calculated overall receiver noise figure of 7.0 db maximum for a 30 Mc IF noise figure of

(*Continued on page 108*)


PRINTED
CIRCUIT
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In Microwave Components
Buy Performance First

In 20 years in this specialized field, Premier has developed unique skills, facilities and design engineering abilities. Whether a standard waveguide unit or an intricate new design, bring your problem to Premier.

PMC

PREMIER MICROWAVE CORPORATION
33 New Broad St., Port Chester, N. Y.
The Waveguide House

Circle Reader Service Card 66

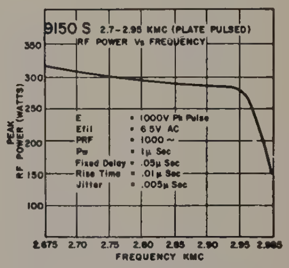
TRAK Type 9150S for
Plate Pulse Service
11/16" Dia.
TRAK
3"
3 ounces

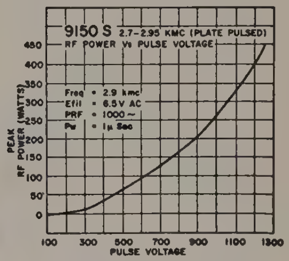
WHERE OVERALL
POWER EFFICIENCY
AND SPACE SAVING
A MUST...

THE NEW RUGGED
TRAK S-BAND
OSCILLATOR

Mechanically rugged enough for use in environments requiring a very high accelerative force, such as in proximity fuse work!

Performance Curves:





SPECIFICATIONS ARE:

Frequency: 2.7-2.95 KMc.
Power Output: 200 Watts peak (test conditions—1 microsec. PW, 1000 PRF).
Power Input: Epp = 1 KV   Ipp = 1.0 amp
Efil = 6.5   Ifil = 240 ma
Duty Cycle: .0025 maximum.
Output Pulse Rise Time: 15 millimicrosec.
Output Pulse Jitter: 5 millimicrosec.
Fixed Delay: 50 millimicrosec.
Vibration: 15 G from 50-2000 cps, 3 axes, less than ±1 Mc FM.
Shock: 100 G, 6ms, 3 axes, less than 250 Kc FM.
Temperature Stability: 2 Mc maximum drift from 0°C. to 90°C.
Mounting: Engineered to customer specifications.

Miniature Microwave Energy Sources, engineered to your specifications.

Write today for new Catalog 61B, full of oscillators for CW, grid pulse and plate pulse service.

TRAK Microwave

TRAK MICROWAVE
CORPORATION
5006 N. Coolidge Avenue
Tampa 3, Florida
REdwood 6-6422

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(Continued from page 107)

1.5 db at a test frequency of 3060 kMc. It has a 250 milliwatt CW burnout rating and is directly substitutable for the 1N831, with improved noise figure. The overall noise figure of this diode is equivalent to that of the 1N21WE.

The 1N831A can be conveniently mounted in coaxial circuits for broadband low-noise mixer applications. It is particularly useful in miniature strip-transmission line circuitry. The point-contact diode junction is mounted in a rugged, hermetically sealed, all-glass case with pigtail axial leads (ribbon leads optional). It is also available in matched pairs for balanced mixer use.

1N831A diodes are immediately available from stock and in quantity. An Engineering Standards Data Sheet on the 1N831A is available.

Circle Reader Service Card 141

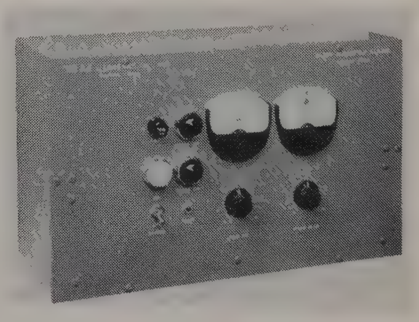
— m w j —

NON-INSERTION DEVICE MEASURES VSWR ON OPEN WIRE LINES

A new, non-insertion device for measuring incident power and VSWR on open wire transmission lines has been introduced by Trak Electronics Co., Inc., Wilton, Conn.

Designated model 2988, the device consists of a probe and a monitor/alarm unit, which provide measurements without complicated setups and operate without interfering with the transmitting cycle.

The probe, which can be clamped on the transmission line at any desired point, operates over a frequency range of 2 - 50 Mc and has a maximum power rating of 50 kw. It offers a directivity in excess of 30 db. Probes are available to meet a variety of wire sizes and spacings.



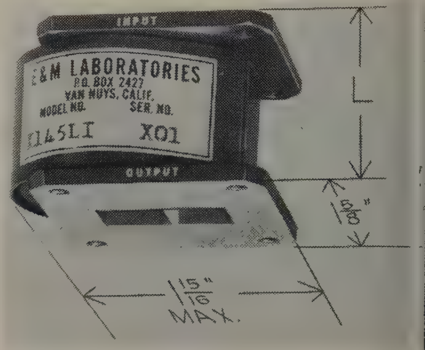
Circle Reader Service Card 142

— m w j —

108 COMPACT ISOLATORS DEVELOPED BY E&M

E&M Laboratories, Van Nuys, Cal., has developed a new series of 108 compact X-band isolators which allow for a versatile selection of standard units to meet custom requirements.

The units are available in lengths of 1, 1 1/4, and 1 1/2 inches and are specified in 600 Mc or 1.1 kMc bandwidth increments. Over the 500 Mc band there is a maximum forward and reverse VSWR of 1.10 and over the extended band it is a maximum of 1.22. The isolation/insertion loss ratios at midband are as high as 100:1. These isolators maintain specified electrical characteristics over an operating temperature range of —40°C to +85°C. Single unit prices are from $125 - $145 depending on length and desired bandwidth.



Circle Reader Service Card 143

— m w j —

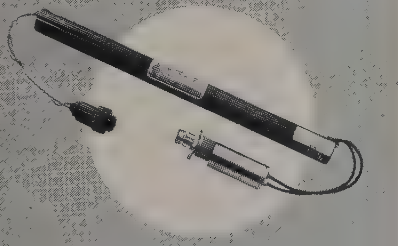
(Continued on page 116)

we're probably a little backward about the way we make Backward Wave Oscillators

Automation, mass production? They're just the thing if you're making automobiles or terminal lugs or even transistors. But for making backward wave tubes, we still hold to the old-fashioned tenets of skilled craftmanship. And we even admit to using such bygone techniques as trial-and-error.

This is simply because we know of no other way to build tubes with the fantastic precision and extremely minute tolerances required in a BWO.

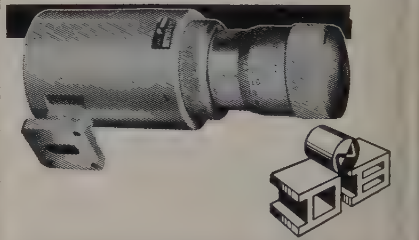
There are some shortcomings to making tubes the way we do. The attrition rate on some of the parts is scandalously high. But when we finish a tube, like the Type OD 1-2 shown below, we **know** it will live up to its specifications, and then some. We **guarantee** a minimum of 500 hours service from it, and are hurt way down deep if it doesn't last several times that long.



Our new brochure tells some of the secrets of making BWOs. Along with it we'll send you a set of specification sheets on our tubes covering the range 1-18 kmc. Write today.

STEWART ENGINEERING CORPORATION

SANTA CRUZ · CALIF.



BROAD BAND CAVITY WAVEMETERS

—gas filled for sustained accuracy

Accuracy is so high these instruments may be used as secondary standards. Units are unaffected by changes in humidity, altitude or barometric pressure. Only 12 sizes serve from 2.6 KMC to 140 KMC. You save budget money on the number of sizes needed. Literature on request.

DE MORNAY BONARDI

DE MORNAY—BONARDI
780 SOUTH ARROYO PARKWAY • PASADENA, CALIF.

Circle Reader Service Card 69

MICROWAVE OSCILLATOR STABILITY AND ITS MEASUREMENT

with emphasis on techniques to measure accurately residual frequency modulation, analyze disturbance frequencies, and determine drift

by R. M. WALLACE
Manager, Instrumentation Section
LABORATORY FOR ELECTRONICS, INC.

Since World War II, the stability required of microwave oscillators has become more and more stringent, and with the requirement, the need to measure stability characteristics. And for the purposes of this discussion, we shall concern ourselves only with measurements on continuous-wave oscillators whose frequency is constant within ±50 kilocycles per second during whatever period of time one may wish to measure stability. Specifically, this requirement implies oscillators with some form of external stabilization.

Microwave oscillators stable to within a few cycles per second are required today in many diverse fields. Perhaps the oldest and still very important usage is as a local oscillator in moving target indicating radar systems. Newer applications include radio astronomy, backscatter phase measurements, determining response characteristics of narrow-band microwave devices, electron paramagnetic spectroscopy, and secondary frequency standards.

In all of these, two kinds of instability are of primary concern: residual frequency modulation, as well as its cause, periodic or non-periodic, which we call short-term instability; and drift, which is long-term instability. The first dependable instrument to measure these instabilities was LFE's 5004, marketed in 1955, which still is the state of the art of competitive stability testers. In 1959, a factor of ten improvement was offered in the Model 5009. Since then, further substantial improvement has resulted in the 5024, to be announced in March of this year.

The 5024 is basically a double superheterodyne receiver of extraordinary stability and refinement. To help explain some of its performance characteristics, a very simplified block diagram is shown below. In operation, the crystal oscillator is varied until a harmonic is found which produces a 30 mc/s output from the mixer. The balanced mixer together with the last multiplier of the multiplier chain is a plug-in unit to facilitate band changes. Four heads are currently available covering the frequency ranges as follows with the sensitivities indicated: 1000 to 3200 mc/s (0 to −35 dbm), 5000 to 6100 mc/s (0 to −25 dbm), 7000 to 10,000 mc/s (0 to −20 dbm), and 9000 to 11,000 mc/s (0 to −12 dbm). Other frequency ranges up to Ku band are available on special order.

After amplification at 30 mc/s, the test signal is heterodyned down to 120 kc/s and further amplified. The inputs to both i-f amplifiers are available for direct injection of test signals. Thus 30 mc/s ±50 kc/s, as well as 120 kc/s ±50 kc/s signals can be analyzed.

In the 2nd i-f amplifier, each stage is a cathode-coupled amplifier which is resistance-capacitance coupled to the next. Because of extreme limiting, the sinusoidal input is converted to very steep-edged square waves. These output pulses are then differentiated, and the positive-going spikes are used to trigger a blocking oscillator which, by means of a delay line, generates square-edged pulses of extremely constant amplitude and duration. There is one constant-energy pulse for each cycle of sinusoidal input to the 2nd i-f amplifier.

It is important to note that, up to this point, the double conversion employed to reduce the input signal to quantized pulses at 120 kc/s does not affect the error information of frequency drift or frequency modulation, provided that the input signal is sufficiently stable to remain within the 70 to 180 kc pass band of the 2nd i-f amplifier. Thus frequency variations (error information) have not been changed. Beyond this point, however, frequency variations are converted to voltage variations.

Now, if the amplitude of these constant-energy pulses is E and the width is t, then the average output voltage E_o as read on a d-c voltmeter is $E_o = E\ t\ f$, where E and t are constant and f is a frequency in the 2nd i-f pass band. By simply providing a bucking voltage equal to the E_o at the center of the pass band (120 kc), a zero-center meter can be used to read drift, plus or minus, about the frequency at the start of a test. On the 5024, two drift ranges are supplied: ±50 kc/s and ±5 kc/s, the latter with a separate zero-adjust control. A BNC jack is also provided for recording long-term drift.

If frequency modulation of the input signal is present (short-term instability), there is an a-c component superposed on the average d-c level, E_o. F-M deviations exist here as jitter of both the leading and trailing edges of the quantized pulse train, pulse length remaining constant. The magnitude of the a-c component is $dE_o = E\ t\ df$.

To recover this component for display as peak f-m deviation, the quantized pulse train is put through a low-pass filter to remove the 120 kc/s carrier and all higher frequencies. Removal of the carrier and higher frequencies leaves only the disturbance frequencies. Five pass bands can be selected: 10 to 150 cps, 10 to 500 cps, 10 to 1500 cps, 10 to 10,000 cps, and 10 to 20,000 cps. All band widths are measured at the 3 db points.

After amplification and detection, the filter output is fed to a meter on the front panel which is calibrated to read peak deviation. Eight full-scale ranges are provided: 10, 30, 100, 300, 1000, 3000, 10,000, and 30,000 cps. A BNC jack is provided for observation by means of an oscilloscope to help determine the nature and hence the origin of the disturbance frequencies.

A separate tunable filter is also available for spectrum analysis of the disturbance frequencies. This filter, or wave analyzer, is tunable from 10 to 10,000 cps, in three ranges, tuning range measured between 1.5 db points. Its Q is 50 across all bands.

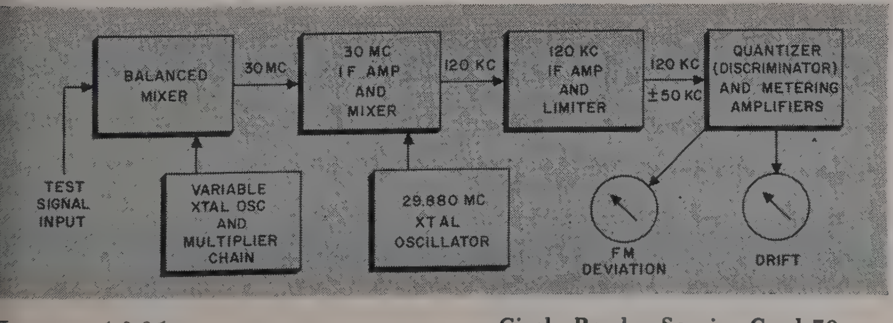
When the tunable filter is used and with reasonable care, the minimum measurable f-m deviation is as follows:

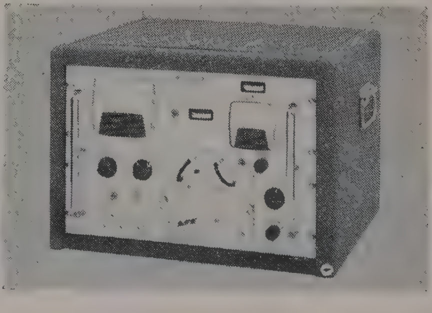
0.2 cps at 30 mc/s and 120 kc/s,
0.3 cps at L band,
0.5 cps at S band,
0.7 cps at C band,
1.5 cps at X band, and
2 cps at Ku band.

The principal advantages of the 5024 over the older 5009 are in the widening of the dynamic operating range of f-m deviation, plug-in heads reduced in cost to about one-third of previous heads, Epsiline (etched circuit) plumbing through C band, and updating of all circuits. And in addition, the 5024 is smaller and lighter.

An interested reader can obtain much more detailed information by requesting Bulletin 5024. For this bulletin, or the answers to particular questions, write Mr. Perry Pollins at the address below.

LABORATORY FOR ELECTRONICS, INC.
Instrument Division
714 Beacon Street, Boston, Massachusetts


BALANCED MIXER
30 MC
30 MC IF AMP AND MIXER
120 KC
120 KC IF AMP AND LIMITER
120 KC ±50 KC
QUANTIZER (DISCRIMINATOR) AND METERING AMPLIFIERS
TEST SIGNAL INPUT
VARIABLE XTAL OSC AND MULTIPLIER CHAIN
29.880 MC XTAL OSCILLATOR
FM DEVIATION
DRIFT



Circle Reader Service Card 70

COMPANY PROFILE

DIELECTRIC PRODUCTS ENGINEERING COMPANY

Raymond, Maine

Dielectric Products Engineering Company, Inc., feels it can best be characterized by one word: Enthusiasm. A desire to learn and to do.

An enthusiastic organization wants a large amount of "firsts" among its contributions to the state of the art. The RF communications art reflects the capabilities of Dielectric's group of engineers and technicians.

Today, in both hemispheres, products designed by Dielectric products are transmitting RF signals into and receiving signals back from outer space.

To understand the forward movement of Dielectric's technology, it is necessary to look at its past.

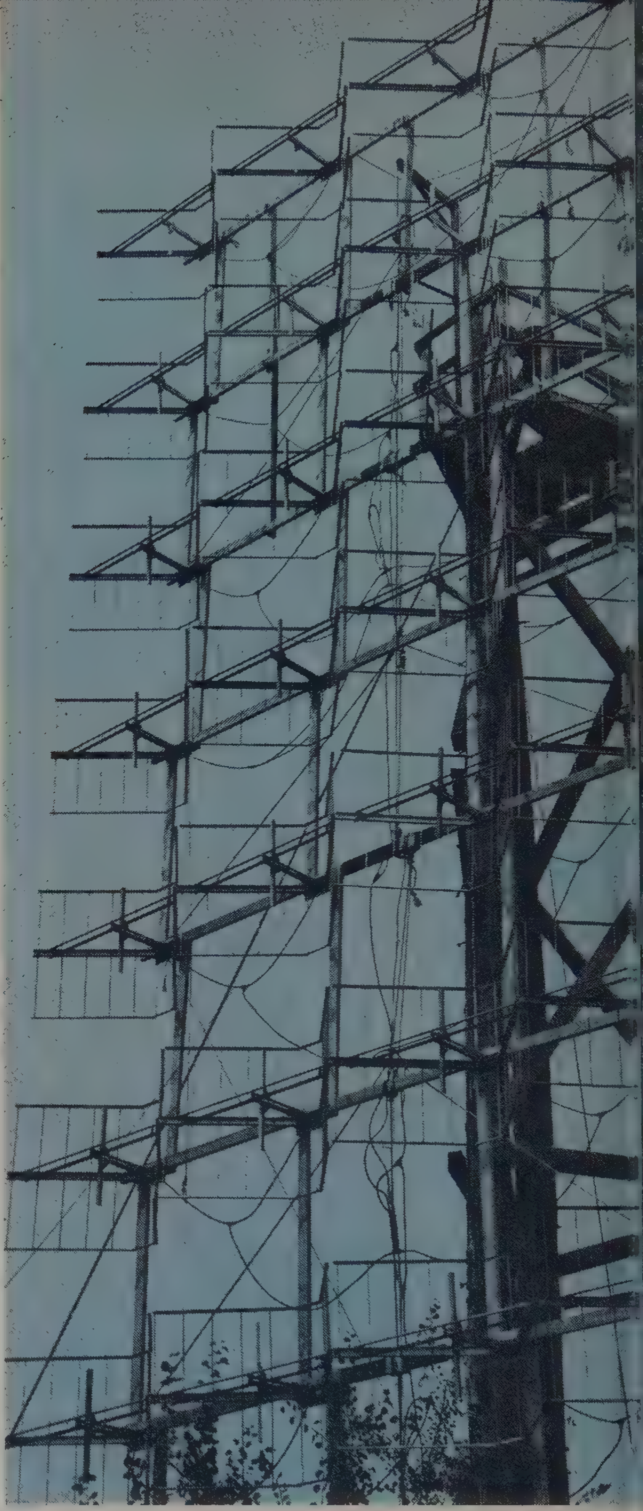
Ten and Twenty Years Ago

Some ten or twelve years before Dielectric Products Engineering Company was granted a corporate charter in the state of Maine in 1952, its founders had a shaping hand in the production of an early air-dielectric rigid coaxial transmission line. This line, after due laboratory development and trials, was launched on the market for amateur radio use. The insulation between inner and outer conductors was ordinary twine, and the outer conductor was more or less a quarter inch in diameter.

An improvement resulted in 1941 when spun glass was used for insulators, enabling the transmission line to handle as much power as one or two watts.

Soon after there came a request from General Electric Company for an improved "hi-power" line to handle much more power than a few watts. The line, which was to have 50 ohms impedance, was required for "Secret Radar."

The urgency of the times and government directives necessitated the use of only those materials most conveniently available. When the "Secret Radar" line wa designed, manufactured and tested, the finally release specifications revealed that ordinary water tubing an standard wrought domestic plumbing elbows had bee incorporated into the job.



One of five high directivity VHF antenna arrays designed an developed by Dielectric for the Trans-Arabian Pipeline Company Used for multi-channel communications and automated pipelin control between offices in Beirut, Lebanon and Saudi-Arabia, th arrays provide over-the-horizon communications at 160 Mc wit 250 watts of power.

The history of this line, however satisfactory or un satisfactory its performance record may have been, wa short. The entire system was lost in the December, 1941 attack on the Hawaiian Islands.

In all of this work J. Robert Marshall, a vice president of Dielectric, and his early associates were actively and influentially engaged. As their work continued during the war years, radar systems were conceived in the VHF range around 200 Mc, so that in this and prior work, Dielectric's founding engineers became well grounded.

Other work they were engaged in before 1950 was the early application of Teflon insulation to coaxial line and components. The Dielectric men determined in a series of experiments that Teflon had superior properties for mechanical stability and industrial insulating at high frequencies. Significant strides, then, had been made since the days of the early twine insulators.

The Beginnings of Experience With Higher Power

As the 1940's moved along, the demands of military radar were for higher power transmitters, and this in turn meant larger diameter air-dielectric coaxial lines. Military specifications began to reflect the experience of severe operating conditions encountered in the various climates. These new rigorous demands required re-appraisal and improvement of mechanical designs in order for them to be compatible with electrical performance.

C. D. "Doc" Brown, holding an engineering degree from the University of Maine, and MS and PhD degrees in mechanical engineering from Harvard University, applied his professional skills and his practical experience in the design of many intricate components. One job was the design of rotary joint sections used in the pedestals of the large rotating radiators for the VHF radars.

After the close of World War II and again after the Korean conflict, when strategic materials used in the military communications systems were released for development of the civilian economy, there began to appear a need for the commercial application of the communications apparatus in which Dielectric's men were well grounded. Their experience in the war effort was quickly turned to good advantage.

One resulting development was an antenna arranged to handle both high and low band VHF reception; it was sold packaged with Allen B. DuMont's home television sets. Special equipment, on which first work was done in 1946, appeared in the commercial networks in the early 1950's and included diplexers and side band filters.

At this time, the Radio Corporation of America required coaxial antenna harnesses. The Dielectric engineering group was expanded to accept the responsibility for the manufacture and test of the required apparatus. Based upon the confidence won by the performance of this assigned task, RCA continued to place development work with the Dielectric electronics group, then a department of Dielectric Products Company, located in northern New Jersey. There, Dielectric designed for UHF a 3 1/8 inch transmission line which met the rigid specifications of TV broadcasting. This line was supplied through RCA, the designer, builder, and marketer of well over half of the nation's TV broadcast stations.

Dr. Charles D. Brown, president and general manager, has had 26 years of broad experience in management, engineering, research and development.

Dielectric Company's early designs, originally conceived during wartime and developed during the surge of the entertainment broadcast industry, contributed heavily to the establishment of Retma standards for transmission line and components. These standards later became EIA standards which are accepted by the military and are in use now with MIL-Type designations.

The anchor insulator design, adapted as EIA standard, was a Dielectric development of the early 1950's. At the same time there appeared the mitered elbow with its advantages over the sweep bend.

The UHF filterplexer, the first to successfully operate commercially, was fabricated, tested, tuned and produced by Dielectric and was installed originally at Bridgeport, Connecticut, for transmission of color TV. Later, in 1952, the apparatus was transported by plane to become a part of the first UHF TV station at Portland, Oregon.

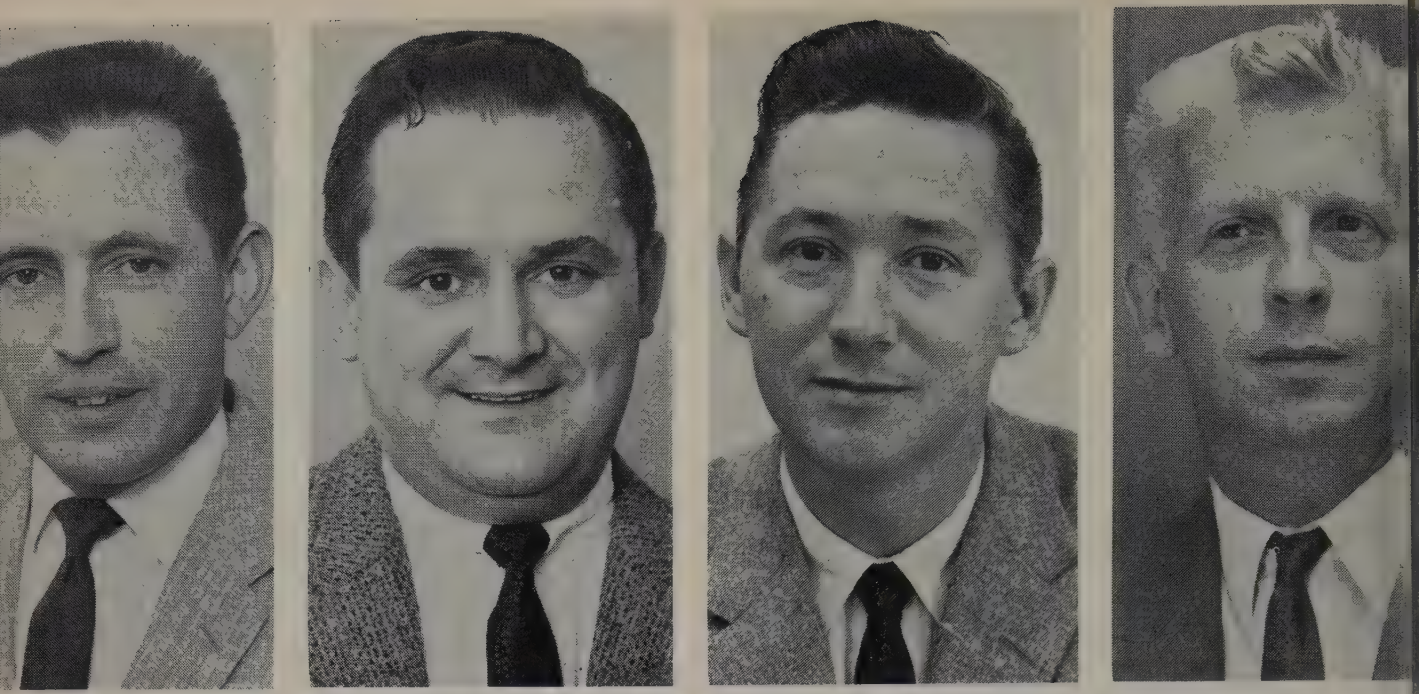
The Move To Maine

Meanwhile, Dielectric had chosen an available industrial building on a forty acre plot at Raymond, Maine, the hometown of Dr. Brown and his brother, Reginald. The activity was moved there from northern New Jersey in 1953 and 1954.

The brothers, J. Robert Marshall, R. P. Sullivan, now vice president in charge of production, and Sidney W. Thaxter, a Portland attorney, became the board of directors. Corporate officers at present are Dr. Brown, president; J. R. Marshall and R. P. Sullivan, vice presidents; Reginald Brown, treasurer, and Sidney Thaxter, clerk.

All of the original invested capital of the corporation was subscribed by the directors and a former associate of the New Jersey operation; his interest was later acquired. From time to time the officers and some other employees of the Company re-invested a substantial part of their salaries and wages, and a few local associates of the group subscribed additional equity capital.

With assistance of mortgage loans and accommodation bank loans made and repaid within short periods,



Left to right are Edward Shively, engineering manager and director of research; Richard E. Fiore and Wilfred G. Beauregard, both senior engineers on the R&D staff; J. Robert Marshall, technical assistant to the president.

the Company annually increased its original net worth, and Dr. Brown managed its finances with enough skill to handle a volume of business always substantially over $1,000,000 annually.

In 1959 Dielectric owners exchanged its closely held shares of stock for a substantial portion of the outstanding shares of the common stock of Ironrite, Inc., a Michigan corporation. At that time, Dr. Brown and Joseph Kinney Jr., who had been associated with Dielectric in various capacities, were elected to the Board of Directors of the now parent Ironrite Corporation. In 1960 the larger part of the sales of the parent corporation were generated by its electronics activity. A smaller but significant volume of its sales were by the Household Appliance Division, which manufactured the home ironer. During 1960 the Warren Manufacturing Company, Littleton, Mass., was added by out-right purchase. There is no funded debt and a healthy ratio of current assets to current liabilities is maintained.

Forecasts for the 1960's envisage modest geometric progression of the Corporation's electronics business. This forecast is based mainly upon four factors. These are: (1) Published market research surveys indicating the continued expansion of the need for RF communications in both military and industrial fields, (2) Parallel increasing market for the specific products of the Company, (3) The basis qualifications of Dielectric for service to the RF communications industry, and (4) the capability of Dielectric's facilities, which it began to broaden in 1956 and 1957 and then augmented vigorously in 1960 along all lines, including laboratory and test area, manufacturing plant, its corps of engineers and technicians, and finally, its administrative and sales groups.

Before a detailed examination of the profile of Dielectric in the 1960's, a summary should be given about the Company's recent technical achievements, as reflected in its products.

Since the surge of TV station installation has subsided, there has been an advancing trend in the FM broadcast market, and here Dielectric is supplying an antenna which has been bought for several hundred installations where it is giving reportedly uniform superior service.

The Distance Early Warning System, operated by Western Electric, includes a substantial measure of Dielectric's coaxial transmission line and accessories. In the Ballistic Missile Early Warning System, Dielectric's first aluminum transmission line, 10 inch id., is found. There, also, are couplers, hybrid networks, phase comparators, and other special components conceived by Dielectric engineers.

A particularly interesting Dielectric "first" is an acutely refined high-power diplexing network of notch filter elements and bandpass coaxial line elements so designed as to permit, simultaneously high-power transmission and low-level reception from the same antenna system. This product, serving at the great Jodrell Bank Radio Telescope in England, where it was installed in time to be highly useful in the start of our Deep-Space Program, resulted from an assignment to Dielectric from Space Technology Laboratories of California.

Isolation between frequencies only 1.5 Mc separated is had as high as 165 db. Twenty kw transmitted signal is transmitted simultaneously with the reception of receiving signals at .002 microvolts. One element of this Dielectric designed and built system includes 30 inch diameter spheres of invar, the manufacture of which, according to precise dimensional specifications, is but one indication of Dielectric's manufacturing resourcefulness.

The '60's at Dielectric

In the first year of the 1960's, new products launched on the market included 30 inch lengths of 50 ohm aluminum transmission line for installation at a Space Surveillance Station operated by the Naval Research Laboratory. Designed by Dielectric, this was supplied through the prime contractors to NRL. Waveguide to coaxial line transitions were shipped.

Folding-type corner reflector antennas for RF communications with 23 db measured gain were sold to a pipeline operator. A new testing instrument was developed and built for plotting impedances continuously, and a differential probe, used in Dielectric's precision slotted line for measurements within .002 VSWR, was also developed.

Engineering developments underway are numerous. There is a high-power open wire switching system, for which an order has recently been received, which will permit the selective coupling of a multiplicity of transmitters and antennas and which will include over 800 switching bay modules. This unit is scheduled to go on stream with the U.S.I.A. in 1962. The system has been purchased for installation and start-up of operations by the Radio Corporation of America.

The Lincoln Laboratories of MIT entrusted to Dielectric the production of high-power resonant ring testing gear, in view of the Company's experience in the design and operation in its own test laboratory of such equipment.

Recently, the first of several prototypes, a 270 KV Klystron DC Power Feed, coax type, designed and tested at over half a million volts by Dielectric at its Bridgton Engineering Center, has been delivered to the Armament Division of the Sperry Rand Corporation. The Company designed and installed, for the purpose of testing this Klystron Feed and for other work, a generator for impulse and sustained high-voltage tests to accommodate over half a million volts.

Engineering is also underway for a Cablemate fitting for use with semi-flexible air-dielectric coaxial lines serving an increasingly wideband of the RF spectrum.

A broadband antenna, which will operate over the band of 3-15 Mc, is under development for a well-known international corporation. Other work is being done in the field of filters for Troposhere Scatter Systems, using the Company's basic engineering achievements in filter work as a background.

Under the guidance of qualified, experienced personnel, recently brought to Dielectric, a start in Solid State Devices for RF use is scheduled for late in the year.

Engineering Center At Bridgton

To accommodate its expanding engineering organization and the supporting Model Shop and test facilities, the Company early in 1960 acquired a 13 acre site and a modern industrial building in Bridgton, Maine, a short distance from its administrative headquarters and manufacturing plant at Raymond.

Edward H. Shively, a graduate of Purdue University with a BS degree in electrical engineering, and a MS degree in electrical engineering from the University of Pennsylvania, is manager of the Engineering Center and director of Research. He joined Dielectric in 1956, bringing with him 17 years of experience as a design and product engineer. He is a holder of a number of patents and the author of Original Design Work in the communications technology field, having to do with both operating apparatus and instruments.

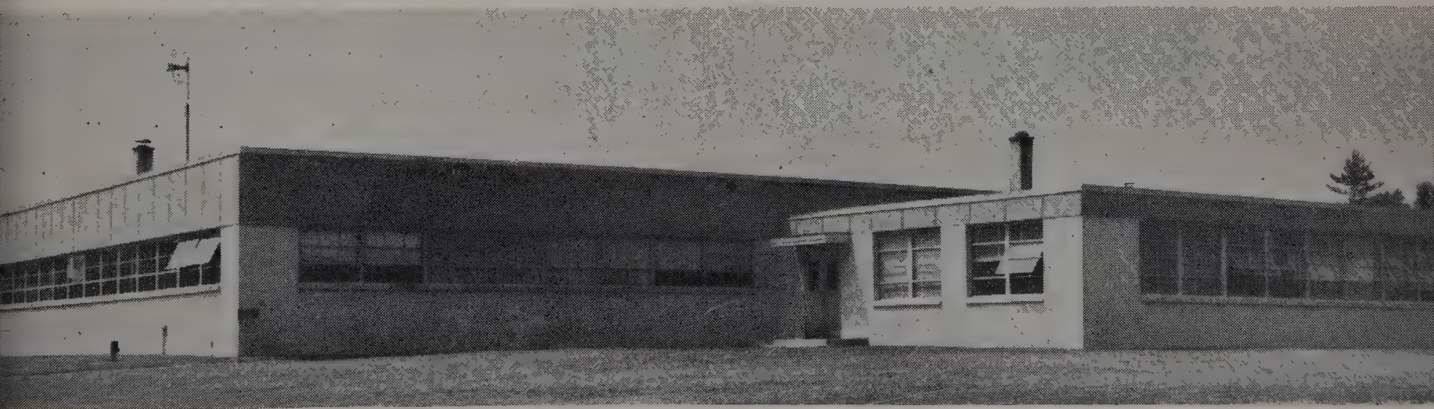
Senior Engineers associated with Shively include, Richard E. Fiore, who joined Dielectric in 1959 from the Missile and Service Radar Section of the Radio Corporation of America. He is group leader and development engineer in charge of activity which encompasses high-level duplexers, high-power variable attenuators, waveguide tuners, and other related devices. Mr. Fiore is currently preparing his thesis for a MS degree in electrical engineering.

More recently another Senior Engineer, Wilfred G. Beauregard, joined Dielectric. His work includes development of microwave test equipment, and the program for Dielectric's entry into the Solid State Microwave Device Field is under his direction. He is a candidate for the Master of Science Degree. Formerly, as Senior Engineer with Raytheon's Surface Radar Microwave Group, he was closely associated with many of that company's activities in connection with the Hawk Missile System.

Development of the Open-Wire Switching System is at present under the guidance of Weldon Brackett, one of the 18 engineers employed by the Company.

At the Bridgton Engineering Center, the work of the engineers is supplemented by a group comprising 65 enployees, 30 of whom are experienced technicians and skilled artisans and draftsmen.

Dielectric's new plant at Bridgton, Maine houses R&D model shop facilities and laboratory testing facilities.



Looking on Panther Pond from Dielectric's outdoor Test Site, there appears the extreme west end of the company's Raymond Plant

The mechanical engineering developments are carried out under Group Leader Don Sewell. H. O. Wittich is in charge of production design work; he is one of the original Dielectric Engineering Group. Francis Noble is the foreman of the Model Shop. Among the engineers is Florence Combes, who has the distinction of being the only female engineering graduate of the University of Maine employed in the State's electronic industry. Donnie VanDusen is the lead draftsman, and Larry Dyer is the plant administrator.

Test equipment at Bridgton includes a 5 kw transmitter for high-voltage and high-current testing of conductors and insulating materials. By the use of resonant circuits of Dielectric design, it is possible to get HF voltage up to 100,000 volts and currents up to 200 amperes. Previously mentioned is the newly installed high-voltage generator for work in the half-million volt range.

The Bridgton Engineering Center is a complete, modern laboratory with generating and measuring equipment for frequencies from 1 Mc - 11 kMc, and RF power testing facilities in frequency range from 10 - 1000 Mc, with average power of several hundred kilowatts and peak powers to 1 megawatt. The Company's land contiguous to the building is used for an antenna site.

Raymond Headquarters and Manufacturing Area

On the forty acre site at Raymond, 17 miles from Bridgton at the south area of the Sebago-Long Lake Resort Area, located on Route 121, is Dielectric's Manufacturing Plant. Here the 40,000 square foot plant has been recently supplemented by the addition of a modern building constructed for the installation of the company's expanded machine shop, operated under the direction of Philip Nobel. This facility was brought into Dielectric with the purchase of the Raymond Machine Company in 1959.

A key department at Raymond is the tool department, where Gordon Brill is the foreman.

In recent months, under the direction of Webster Charlton, the Company's welding consultant, teams of welders skilled in the fabrication by welding techniques of both copper and aluminum, have been certified to meet the high standards of USAF.

Facilities and techniques at Raymond are complete for the handling, manufacture, and assembly of the Company's products, using ceramics, plastics, various dielectric materials, and such metals as invar, aluminum, copper, berillium copper, and other materials of modern usage.

There are facilities for iriditing and spray painting, and for careful packaging, which assists in transporting the Company's products to assure arrival in good condition, ready for use at sites all over the world. The Raymond manufacturing operation is under the direction of Vice President R. P. Sullivan. Production test facilities, through which components pass before shipment, are directed by Phil Chase. Production control is directed by Ira Milliken.

George Edson, manager of quality control, reports directly to Dr. Brown as the general manager. Order processing manager is Leonard Robinson, assisted by Herman Dobson. H. D. Lord is the purchasing agent. Arthur Robinson is the chief accountant and Eleanor Plummer is in charge of clerical personnel.

In charge of customer development is R. M. Hasch, engineering graduate of the University of Illinois. In the Philadelphia area, A. H. Super acts as sales engineering representative.

Manufacturers representatives appointed in 1960 include the James L. Highsmith & Co., with offices in Charlotte, North Carolina; Huntsville, Alabama; and Richmond, Virginia. Arco Engineering Company, with headquarters in Washington, D.C., services that area and the government areas at Rome, New York, and Fort Monmouth, New Jersey. Dayrand, Ltd. represents the company in Canada at the Montreal office. In the Boston area, Robert W. Gray, Inc. at Wellesley are sales representatives. Addelco of West Roxbury, Mass., handles the Company's instrument sales in the Northeast part of the country. The John A. Green Company, located in Dallas, services that area. At present, other parts of the country are taken care of from the Company's headquarters. It is expected that sales activities in 1961 and 1962 will be stepped up in the active Syracuse, New York area, in the Midwest, and on the West Coast, with a look at the export markets following.

Recently, an evaluating team acting for one of the country's largest armament and electronics firms surveyed the Company's facilities and commented that the Dielectric team appeared "energetic, resourceful, and competent." An initial order resulted.

The Company hopes that its efforts to serve its trade may be reflected in a backlog of business in the future, even more than at present. The backlog now is the largest in its history.

YOU'RE STILL TUNED IN, HERR PROFESSOR DOPPLER!

Back in 1930, your principle helped provide the first step in the development of radar. Since that time, radar has grown up . . . always depending on the Doppler shift to measure the velocity of a moving object. Now, we're about to put your principle to work again; this time as an integral part of the Bombing Navigation System for the B-52 weapons system. If you would like to help us apply yesterday's principles, like Doppler's, to important projects like B-52 navigation, and if you have a BS, MS or PhD in EE, ME, Physics or Math, please contact Mr. G. F. Raasch, Director of Scientific and Professional Employment, Dept. I, 7929 S. Howell, Milwaukee 1, Wisconsin.

All qualified applicants will be considered without regard to race, creed, color or national origin.

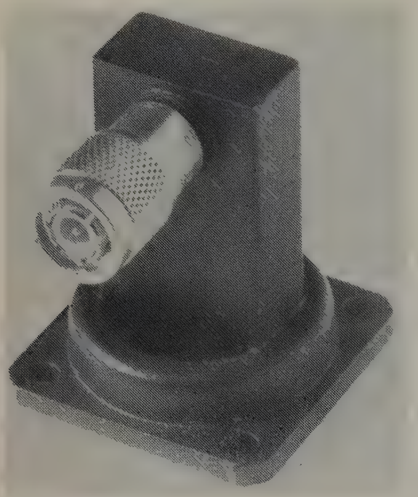
AC SPARK PLUG ⚛ THE ELECTRONICS DIVISION OF GENERAL MOTORS
MILWAUKEE • LOS ANGELES • BOSTON

AC

New Products

(*Continued from page 108*)

NEW SERIES OF WAVEGUIDE ADAPTERS AVAILABLE



General RF Fittings, Inc., Boston, Mass., oducers of RF coaxial connectors and cable assemblies, announces a new series of Waveguide Adapters for use in the test laboratory, in the field, or wherever a transition from coax to waveguide is needed.

The units adapt coaxial cable to rigid waveguide through the use of either male or female TNC coaxial connectors and a short length of waveguide with a flange.

Coaxial fitting mates with standard TNC connectors, waveguide mates with standard X or C flanges. Waveguide adapters are also available TM to waveguide.

The Waveguide Adapters are available in three models in 3.2 - 10.8 kMc range with a maximum VSWR of 1.12 over the specified band. All units are individually tested and calibrated for lowest VSWR. Impedance is 50 ohms.

Circle Reader Service Card 144

—mwj—

108 COMPACT ISOLATORS DEVELOPED BY E&M

E&M Laboratories, Van Nuys, Cal., has developed a new series of 108 compact X-band isolators which allow for a versatile selection of standard units to meet custom requirements.

The units are available in lengths of 1, 1 1/4 and 1 1/2 inches and are specified in 600 Mc or 1.1 kMc bandwidth increments. Over the 500 Mc band there is a maximum forward and reverse VSWR of 1.10 and over the extended band it is a maximum of 1.22. The isolation/insertion loss ratios at midband are as high as 100:1.

The isolators maintain specified electrical characteristics over an operating temperature range of —40°C to +85°C.

Single unit prices are from $125 - $145, depending on length and desired bandwidth.

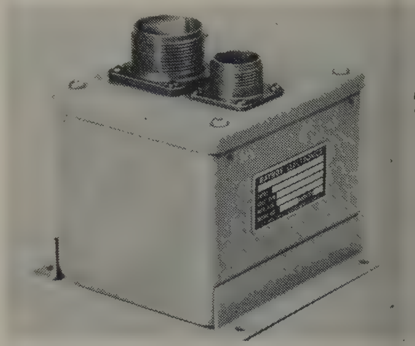
Circle Reader Service Card 145

—mwj—

BAY-ROY DEVELOPS REMOTELY OPERATED SELECTOR SWITCH

The Bay-Roy Electronics, Inc., Cleveland, Ohio, specialists in transmission line and antenna components, announce the development of a remotely operated 8P2T Selector Switch.

The unit was designed and developed to operate banks of coaxial switches used in satellite tracking systems. It features



reliable rugged light weight construction gasket sealing, fast switching time and convenient flange mounting. Other selector switching configurations and actuator voltages are available for other applications. The unit does not require continuous actuating power in any switch position. Technical characteristics are: Switching Configuration — 8P2T; Contact Ratings — 5 amperes (not break); Actuating Voltage — 115 volts ac; Life — 40,000 Actuations; Switching Time — 100 msec.

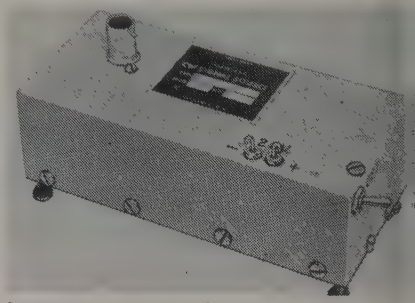
Circle Reader Service Card 146

—mwj—

17 OZ. UHF TRANSMITTER GIVES ACCURATE CW SIGNAL

A new model UHF Telemetering Transmitter that provides an accurate and stable CW signal for radio direction finder tracking of missiles or vehicles has been announced by Frontier Electronics Co., Cleveland, Ohio.

The TT-1001 Model 7 is a completely transistorized CW transmitter with a self contained, regulated power supply. Silicon transistors are used throughout. The unit



is easy to install, flexible in application and has high accuracy and stability characteristics under extreme environmental conditions. Frequency is 225 - 245 Mc, frequency accuracy is better than 0.01 per cent, frequency stability is better than 0.0 per cent and power output is 260 milliwatts. Weight is 17 ounces with battery, 6.5 ounces without.

Circle Reader Service Card 147

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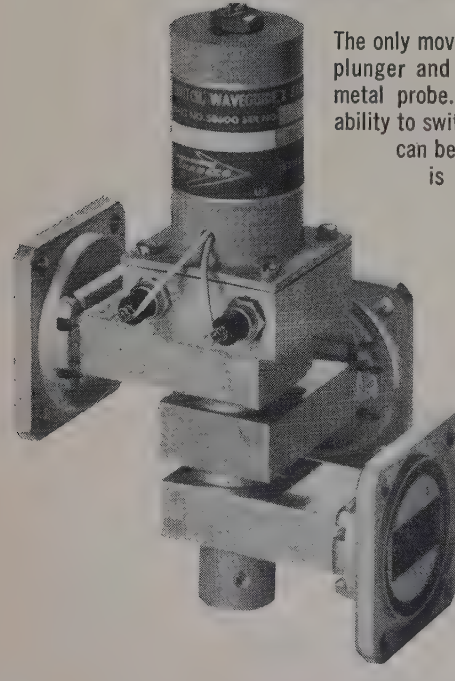
(Continued on page 117)



PROBING THE "TRANSPROBE" WAVEGUIDE SWITCH

The only moving parts of the "Transprobe" are solenoid plunger and a light weight, dielectrically supported metal probe. Result... greater flexibility, longer life, ability to switch under full waveguide power. The design can be applied to any waveguide size. Unit shown is a single-pole-double-throw, X-band switch. The design is equally successful for adaptation to SPDT, SP3T, transfer switch or special configurations. Typical specifications: Frequency... 8.2-12.4 KMC, VSWR...1.20, Insertion Loss...0.2 db, Crosstalk...35 db, Life...2,000,000 operations. To probe more thoroughly the unusual advantages in this new approach to waveguide switching write Transco Products, Inc., 12210 Nebraska Avenue, Los Angeles 25, California.

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"Pioneer Manufacturers of Towers of All Kinds"

Circle Reader Service Card 72

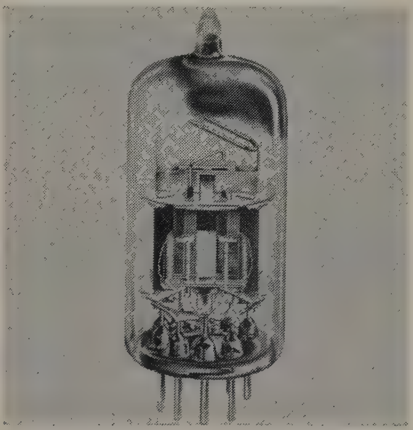
New Products

(Continued from page 116)

MINIATURE PENTODE HAS TRANSCONDUCTANCE OF 50,000 MICROMHOS

The type 7788, a miniature nine-pin pentode incorporating two frame grids (control grid and screen grid) to attain a transconductance of 50,000 micromhos has been announced by Amperex Electronic Corp., Hicksville, L. I., N. Y.

The 7788 is designed for use in broadband amplifying circuits such as radio and TV relay systems, coaxial telephone lines, radar equipment and oscilloscopes.



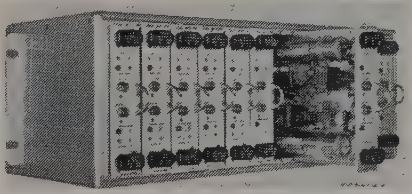
Immediately available in production quantities, the type 7788 has a figure of merit of 410 Mc. Equivalent noise resistance is 60 ohms, triode connected, and 100 ohms, pentode connected; and noise figure is 50 - 100 per cent better than similar tubes. Typical operating current is 35 ma, while average screen grid current is only 5 ma.

Circle Reader Service Card 148

—mwj—

COLLINS INTRODUCES TRANSISTORIZED MICROWAVE CARRIER

A completely transistorized microwave carrier system has been introduced by the Texas Division of Collins Radio Co., Dallas, Texas.

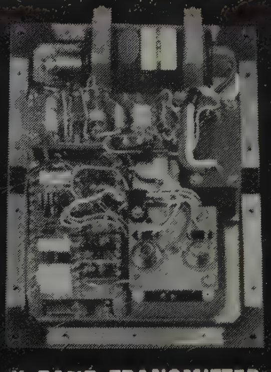


Designated the Collins MX-106 Microwave Carrier System, it provides maximum reliability and efficiency for multi-channel communication, yet requires only one-fifth the rack space and consumes only one-eighth the power of similar tube equipment. The system handles 600 voice channels whose quality meets or exceeds toll circuit requirements. An initial low chan-

(Continued on page 119)

ACF

MICROWAVE EQUIPMENT



X-BAND TRANSMITTER TYPE NO. 501

COMPACT DESIGN WITH NO PERFORMANCE PENALTIES. SYSTEM-TESTED FOR OPERATIONAL SPACE VEHICLES. ENGINEERED TO MEET COMPLETE MILITARY MISSILE SPECIFICATIONS.

Frequency Range: 8900 mc to 9400 mc
Wave Guide Power Output: 1,000 Watts, peak
Duty Cycle: 0.002 (maximum)
Pulse Width: 0.45 u seconds ± 0.1 u seconds
Minimum Pulse Spacing: 90 u seconds
Modulation: Pulse
Modulator: Solid State
Input Voltage: 24-30 V DC @ 1 amp.
6 V DC @ 0.45 amp.

May be operated as a free-running pulse transmitter or used with a commutator type telemetry unit capable of providing PPM triggering signals at rates up to 900 bits/sec.

Standard designs modified to meet specific requirements. Complete manufacturing and engineering resources supported by local field service. Full line of components for L, S, C or X-Band Frequencies.

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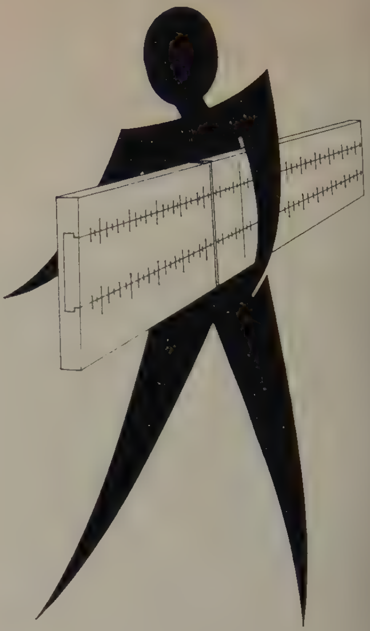
QUESTION: What is as precious to a microwave engineer as his slide rule?

ANSWER: The new **microwave engineers' handbook.** Packing 150 pages of previously unassembled technical data into a desktop working tool, it should easily become the greatest boon to the microwave engineer since the invention of the slide rule. Distributed free to subscribers of *the microwave journal.* Publication date is October. Space deadline is August 1st.



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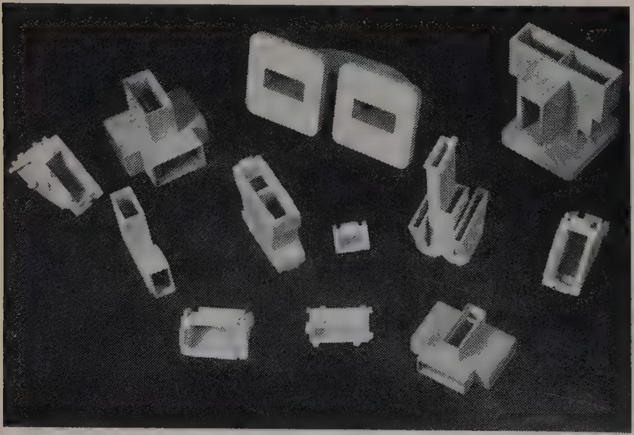

CASTINGS IN
BRAZEABLE ALUMINUM
BERYLLIUM COPPER

RODÉ, INC.
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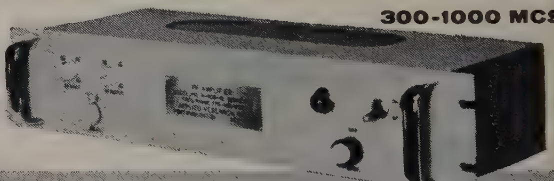
tunable RF AMPLIFIER

300-1000 MCS



- Low Noise Figure
- Tuning Range to 150 mcs
- 10 mcs Bandwidth
- Single Control Tunability
- High Gain
- High Reliability

This versatile and dependable UHF RF amplifier permits the user to vary the frequency of the amplifier up to ±10% of nominal center frequency (not to exceed 150 mcs range) in the frequency range of 300 - 1000 mcs. Tuning is done by means of a slotted shaft accessible through the front panel.

The amplifier is supplied complete with power supply, mounted on a 3½" high panel to fit a standard rack.

GENERAL SPECIFICATIONS — MODEL UH-2 (AT)

Center Frequency	300 mcs to 1000 mcs
Freq. Range (tunable)	Up to ±10% of nominal F° (not to exceed 150 mcs range)
Bandwidth	10 mcs nominal
Noise Figure	5.5 db at 400 mcs; 9.0 db at 1000 mcs
Gain	18 db nominal (representative values)
Source and Output Impedance	50 ohms

Write for further information.

Applied Research inc.
76 South Bayles Avenue Port Washington, N. Y.

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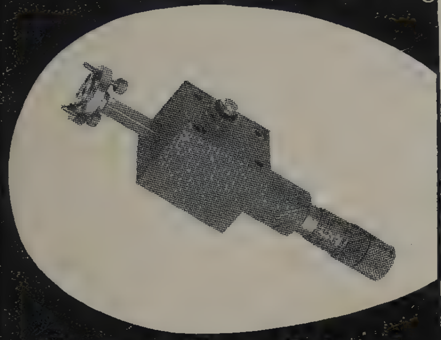
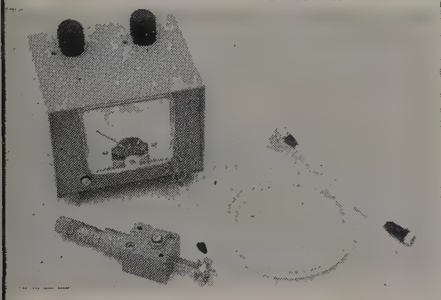
NEW FROM LIECO

MILLIMETER BOLOMETERS®



Super Sensitive!

75 ohms per milliwatt. Optimum matching 13 db to 30 db greater sensitivity than a 1N53 crystal at 70 kmc. Power as low as 10^{-8} watt can be readily detected with standard amplifiers. Perfect repeatability. No delicate handling required. In guide construction results in a rugged element with unlimited shelf life and stable characteristics. Companion bias supply is battery operated with wire wound resistors to insure low noise level.



SPECIFICATIONS & PRICES			
	Model No.		Price
Bolometer Mount	32P1	32Q1	$260.00
Element	33P	33Q	125.00
Bias Supply	B101	B101	90.00
Frequency kmc/s	50-75	60-90	
Waveguide	RG-98/U	RG-99/U	
Flange	UG-385/U	UG-387/U	
RF Power Range	10^{-8} w to 10^{-3} w		
Sensitivity	75/mw nominal		
Linearity	over entire power range		
Time Constant	100 microseconds		
Power Rating	3 mw Total (typical)		
Bias Current	2.2ma (maximum)		
Connector Type	Microdot		

For use in power measurements with standard wattmeter bridges, selected bolometers can be supplied on special order.

® U.S. Patent 2,836,800

LIECO INC

SYOSSET INDUSTRIAL PARK
130 EILEEN WAY
SYOSSET, L. I., N. Y.

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New Products

(*Continued from page 117*)

nel density system can be expanded easily and economically at any time.

The MX-106 uses the frequency division principle with single sideband, suppressed carrier techniques. Frequency allocations, sideband allotment, and carrier levels are compatible with Collins MX-103 Carrier, Western Electric L-Type Carrier, CCITT and others. To achieve maximum channel density, multiple modulation techniques are used to form a composite baseband signal for transmission by broadband transmitting equipment.

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VIDEO CRYSTAL TEST SET ANNOUNCED

The new AIL Type 393 Video Crystal Test Set which provides a rapid and accurate method to measure the tangential sensitivity of video crystals, has been announced by Airborne Instruments Laboratory, Deer Park, Long Island, N. Y.

Using a DC technique, the tester does not require the operator's familiarity with microwave measurements to obtain accurate readings. In addition to measurements of single crystals, the Type 393 will find wide use in selecting crystals for matched operation.

The Type 393 is completely portable and battery operated for field as well as laboratory operation. Price $299.00

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PAPERS

We wish to emphasize again that "the journal" is interested in receiving papers from the industry.

Papers can be addressed to: "the microwave journal," 1330 Beacon St., Brookline 46, Mass.

— *m w j* —

CHANGE OF ADDRESS

When submitting a change of address, please complete the subscription card inside the back cover of the magazine. Include the address at which you have been receiving *the microwave journal*, and allow one month for the change to become effective.

ACF MICROWAVE EQUIPMENT

C-BAND TRIODE PULSED OSCILLATOR MODEL NO. 338

SPECIFICALLY DESIGNED FOR TRANSMITTER SERVICE IN MISSILE AND DRONE TYPE RADAR BEACONS.

Maximum miniaturization with no performance penalties. System-tested for operational space vehicles. Engineered to meet complete military missile specifications.

Frequency Range: 5400 to 5900 mc

Power Output: 1.5 kw min. (200 mc tuning range)
1.0 kw min. (500 mc tuning range)

Stability: ± 3 mc over the most stringent air-borne environmental conditions.

Pulling Factor: Less than ± 2.5 mc for 1.5 VSWR, all phases.

Pushing Factor: Less than 5 kc/peak ma.

Load Variation: Can withstand VSRW's of 6:1 at any arbitrary phase without impairing life expectancy.

Standard designs modified to meet specific requirements. Complete manufacturing and engineering resources supported by local field service. Full line of components for L, S, C or X-Band Frequencies.

ACF Beacons have qualified for more major satellite and missile programs than any other beacon.

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11 PARK PLACE, PARAMUS, N. J.
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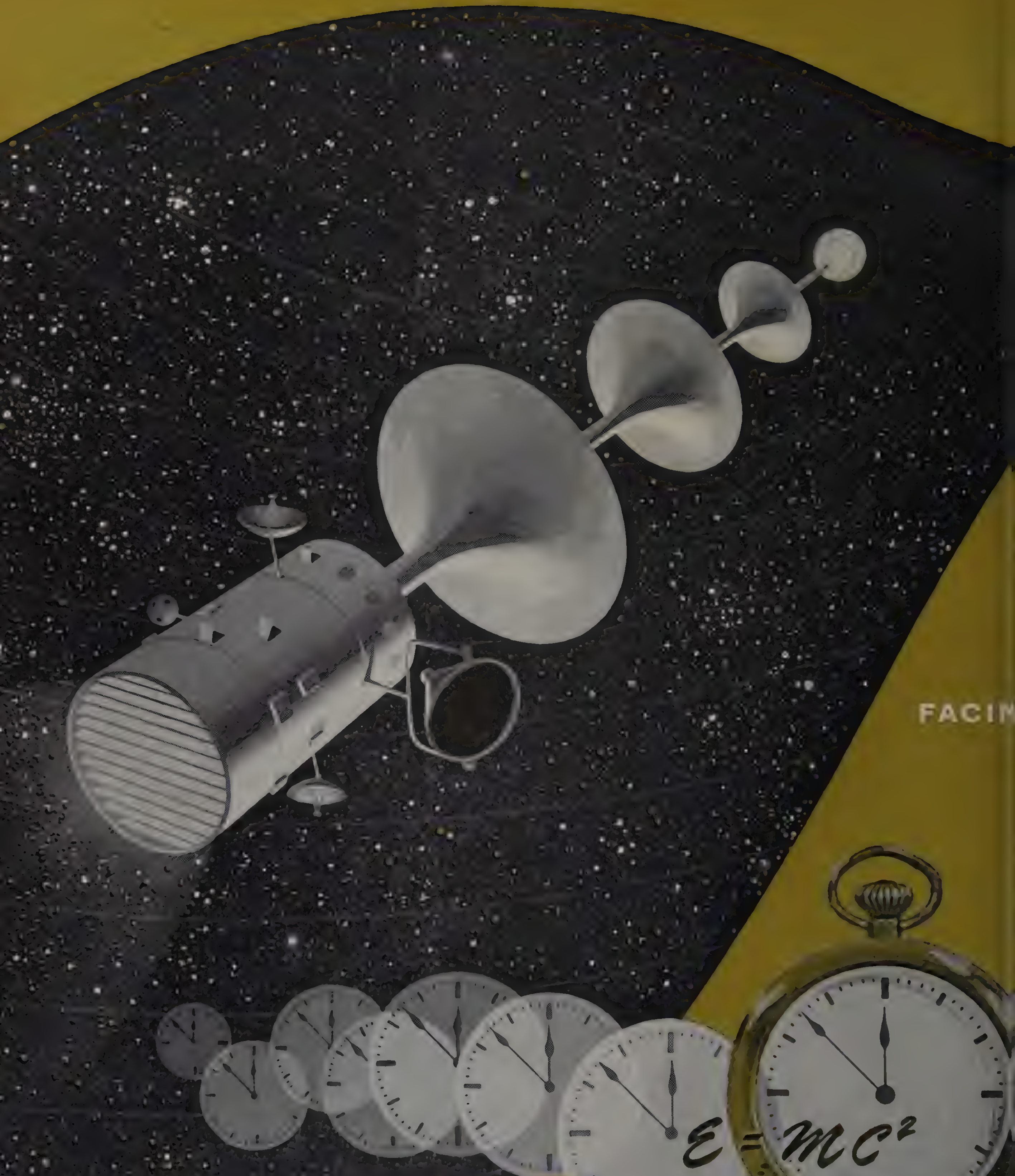

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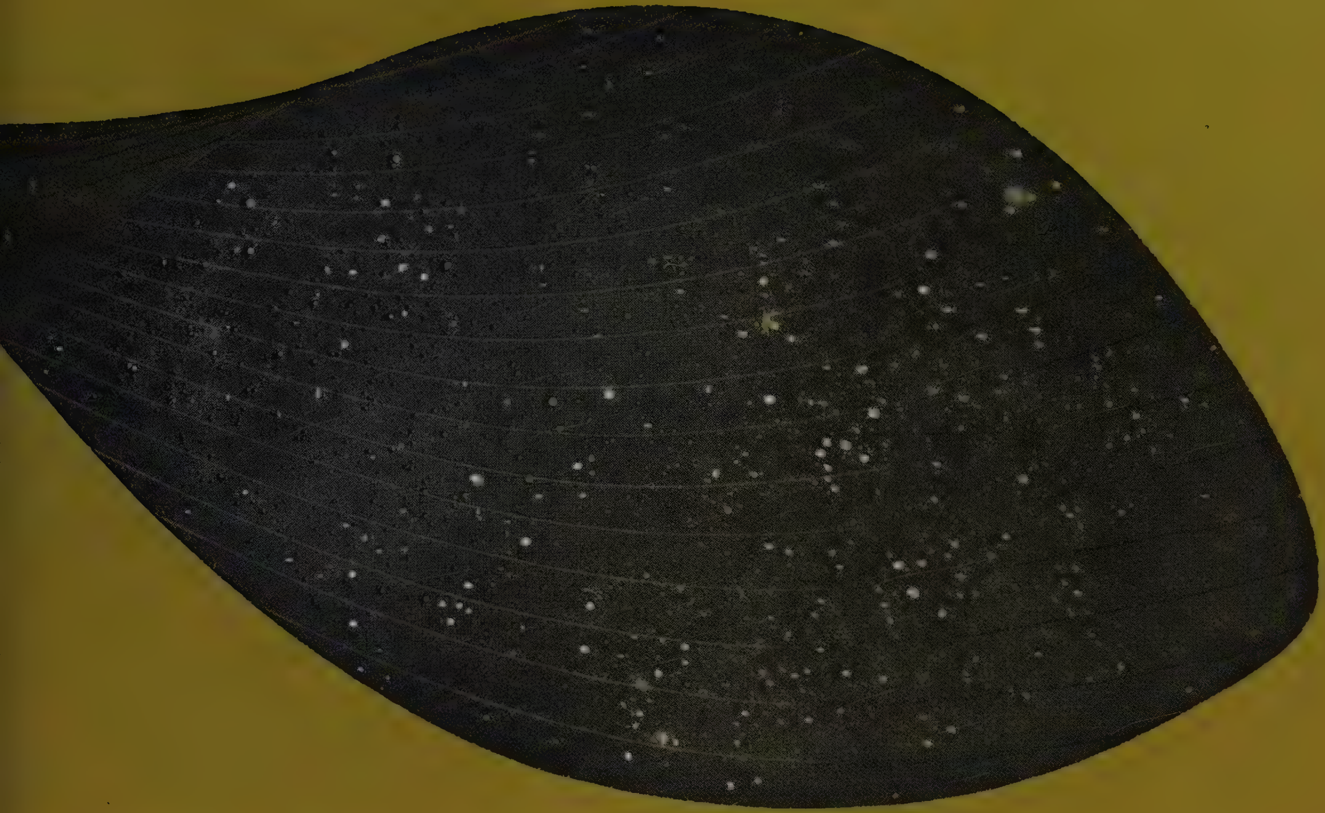


HE FOURTH DIMENSION IN PROPULSION DEVELOPMENT

Whether the universe has a "saddle shape," or any shape at all, is a matter of interesting conjecture. The matter of space travel, however, is the subject of intense experimentation. A nuclear/thermionic/ionic propulsion system, currently being studied at Lockheed Missiles and Space Division, might well become the power source for space vehicles.

Its design incorporates a nuclear reactor only one foot in diameter, generating heat at a temperature of 1850°K. This is transmitted to banks of thermionic generators, converting the heat directly into electrical energy for the ion beam motor which uses cesium vapor as a fuel. The entire system is designed without any moving parts, minimizing the possibility of failure.

Lockheed's investigation of propulsion covers a number of potential systems. They include: plasma, ionic, nuclear, unique concepts in chemical systems involving high-energy solid and liquid propellents, combined solid-liquid chemical systems. The fundamentals of magnetohydrodynamics, as they might eventually apply to propulsion systems, are also being examined. Just as thoroughly, Lockheed probes all missile and space disciplines in depth. The extensive facilities of the research and development laboratories—together with the opportunity of working with men who are acknowledged leaders in their fields—make association with Lockheed truly rewarding and satisfying.

Lockheed Missiles and Space Division in Sunnyvale and Palo Alto, on the beautiful San Francisco Peninsula, is an exciting and challenging place to work. For further information, write Research and Development Staff, Department M-24D, 962 West El Camino Real, Sunnyvale, California. U.S. citizenship or existing Department of Defense industrial security clearance required. All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Lockheed / **MISSILES AND SPACE DIVISION**

Systems Manager for the Navy POLARIS FBM and the Air Force AGENA Satellite in the DISCOVERER and MIDAS Programs

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA • CAPE CANAVERAL, FLORIDA • HAWAII

Officers and Board of Directors maintain close control of policy at monthly meetings. Left to right are K. Petty, secretary and legal counsel; F. L. Berry, director; W. R. Rambo, director; C. V. Barker, director and treasurer; W. E. Ayer, director and president; P. D. Strum, director and vice president; O. G. Villard, Jr., director; and S. S. Wyman, assistant treasurer and accounting counsel.

INTRODUCING

APPLIED TECHNOLOGY, INC.

Palo Alto, California

Although the "broad-brush" name Applied Technology was chosen to imply a broad area of system development capability, more than three-quarters of its business is in the field of microwave systems. Applied Technology specializes in the development of special receiving and transmitting systems to meet custom requirements on a quick reaction basis, with the final equipment meeting rigid standards of workmanship, packaging, and appearance.

History

In the Spring of 1959 the principal founder, William E. Ayer, quickly found support from Peter D. Strum for his hopes to organize a company to provide such services. They shared a feeling that most of the larger companies involved in this sort of activity did not expeditiously provide the required link between the laboratory and the operational user.

When stock was taken of their personal resources, they decided that a modest activity could be undertaken, with the fond hope that a "snow-balling" process would allow growth to a substantial size. From the outset the founders were determined to resist the temptation to obtain outside backing at the expense of lost equity. On the other hand, it was felt that employees and others on the team would be provided with a strong motive to produce their best results if they were invited to participate in the ownership. A sliding scale for such stock participation was established at the outset.

With only the personal resources of the two original founders, Applied Technology was organized in April 1959, and operations began almost immediately in a single office in Palo Alto. Within a month, half of a building in the Palo Alto Industrial Park was leased providing 4200 square feet of combined office and laboratory space.

During these early days, first a business manager and then a secretary were added to the staff. The choice of a business manager, in the person of C. V. Barker, as the third member of the team was based on the feeling that someone other than the executive and technical personnel should be responsible for the accounting and general management function. This should not be construed to mean that the founders were not interested or competent in the area of organization and man agement but reflected their need for having freedom from day-to-day details of office and account management.

During the first summer of operation Ayer and Strum spent much of their time preparing proposals in the areas of microwave electronic countermeasures systems and receiving systems. They were soon awarded a small subcontract for a receiving system and a substantial prime contract for an ECM system. The ECM system was carried "from concept to reality" in four months, the "reality" being two completely engineered, finished equipments for flight evaluation. Early success in these flight tests provided the basis for substantial re-orders and essentially got Applied Technology off the ground.

Though all has not been easy sledding since that time, the growth rate has averaged about one new employee per month. Weathering the recent business recession without having any idle periods or lay-offs is regarded as a good omen. In fact, a substantial backlog has been maintained since the first few months of operation. Prospects for "snow-balling" now appear very bright.

Key Personnel

President Bill Ayer brought to the company a broad background in administration and in engineering systems applying advanced traveling-wave and related beam tubes to military problems. In the applied electronics program at Stanford University, successive promotions resulted in his becoming head of the Systems Development Section. Immediately prior to organizing Applied Technology he had served for two years as vice president and director of Engineering at Granger Associates. It was the de-emphasis of system development work at Granger that triggered the organization of Applied Technology.

Co-founder Pete Strum brought a background in low-noise receiving systems and noise measurement techniques. For eight years at Airborne Instruments Laboratory he had been instrumental in the development of low-noise radar and reconnaissance receivers and commercial products in the areas of noise generation, automatic noise figure indication, and mixer crystal testing. An automatic direction finder for which he was project engineer, the AN/ARA-25, is still the standard UHF direction finder on many military aircraft. As vice president at Ewen Knight Corporation he was responsible for developing low-noise radio-astronomy receiving systems, including the most sensitive radiometer in existence at that time.

After four months of operation, Robert R. Johnson was added to the staff as a project engineer. He brought to the staff more than ten years of experience in the development of military systems. His areas of activity had included establishment of an antenna testing facility, design of missile control systems, development of ASW equipment, and development of ECM and reconnaissance systems.

In January 1960 John L. Grigsby was appointed chief engineer. His eleven years of experience were principally in system development in ECM and reconnaissance systems. Since his appointment as chief engineer, Grigsby has been in charge of the engineering program in all areas of the company's business, while also carrying on the development of an experimental advanced ECM system and numerous broad-band low-noise amplifiers.

After somewhat more than a year of operation, it became apparent that the growth of the new enterprise called for the addition of someone devoted exclusively to marketing the company's services. John B. Pettegrew was added to the staff in the fall of 1960 as engineering marketing manager. His technical background was as a group leader in QRC countermeasures equipment development at Hallicrafters and as chief engineer at Menlo Park Engineering, establishing a product line of microwave instrumentation equipment. Pettegrew has been actively establishing marketing representation throughout the country, with representation already established in Washington, Dayton, and the Far West and Southwest.

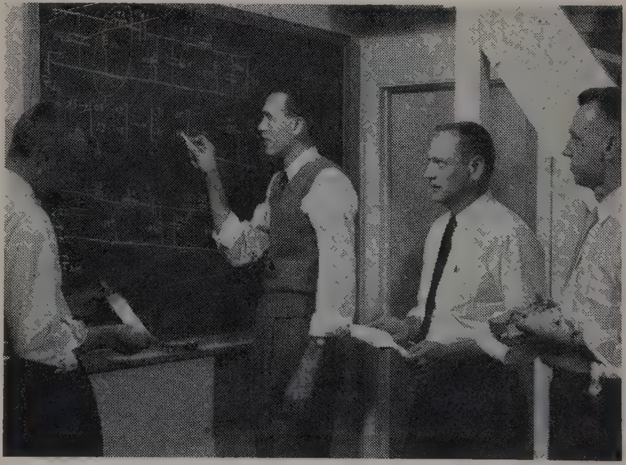
Company Activities

During its first two years, Applied Technology has been operating in the 4200 square-foot half of a modern plant in Palo Alto. This month the company will move into the entire building.

This doubling of the available space comes just in time to avoid overcrowding. Furthermore, present prospects for substantial additional growth mean that soon even more space will be needed.

An unusual method of company operation by most standards is that more than seventy per cent of the development work on new systems and devices has been done on a fixed-price basis. Whenever the senior staff has a firm "feel" for the solution of the customer's problem, a fixed-price quotation is made. The use of fixed-price contracts has proved beneficial to both the customers and the company. The higher degree of risk in this type of operation is recognized, but the self-confidence of the staff has so far been justified.

Throughout the initial period a balance has been maintained between the engineering staff and the technician and overhead staff. This reflects a concerted



Senior engineering staff members confer on design problem. Left to right are R. R. Johnson, project engineer; Dr. J. L. Grigsby, chief engineer; Dr. W. E. Ayer, president; and P. D. Strum, vice president.

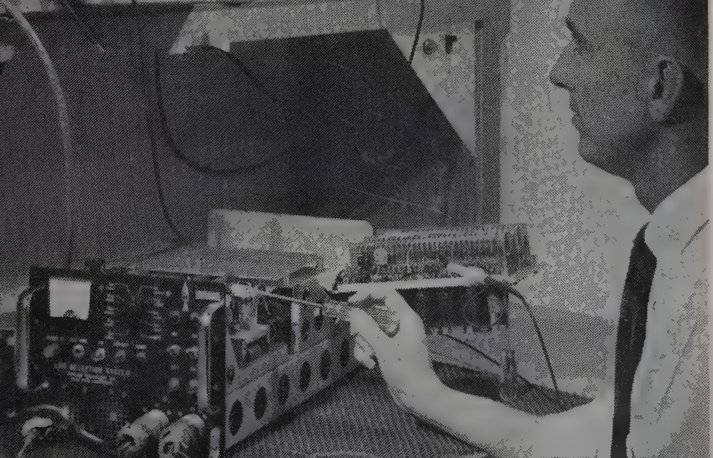
effort to carry on only those activities which spread the operating load among engineers, technicians, and production workers in a nearly constant ratio.

A principal activity of the company to date has been development and fabrication of electronic countermeasures systems. This work was begun as a result of a problem stated by a customer and culminated in the flight testing and proving of the principles involved. Along similar lines, reconnaissance receiving systems covering frequency ranges all the way from 30 Mc to 40 kMc have been developed. Among these were airborne and ground-based receiving systems covering the 10-40 kMc frequency range in two octave bands. To the microwave engineer this octave coverage is a bit unorthodox; but, in this instance, it effected a large saving in complexity of equipment and operating procedure.

Although a principal portion of the activities of the company is not in the development of components such as mixers and antennas, these devices may be developed when required. For instance, attempts to find a suitable 10-20 kMc mixer from an outside source were fruitless. When the search was abandoned, Project Engineer R. R. Johnson in a few weeks developed a mixer having uniform response within 2 db over the entire frequency range. Similarly, in the field of antenna design, a need for broad-band circularly polarized horns was met partly from within the company and partly from outside suppliers. The in-house development was facilitated by a small model range on the roof of the company's plant.

Another field of associated work is in the realm of antenna isolation. For certain systems, antennas mounted near each other in a radome and oriented in the same direction had to be isolated from each other by 80 db. Staff discussions with others in the industry indicated that such isolation was out of the question. However, again on the small roof-top antenna range, tests were made showing that isolation in excess of 80 db could in fact be achieved over a broad frequency range.

R. R. Johnson, project engineer, adjusts microwave radar deception system.



Most of the non-microwave activity of the company has been in the field of broadband low-noise RF and IF amplifiers. A particularly intriguing problem solved by John Grigsby called for the uniform amplification of a band of frequencies from 30 to 260 Mc, distribution of this band to six isolated output terminals, all with a low noise figure. An efficient solution was provided by having all stages use identical miniature triodes in an unusual circuit arrangement. Prior alternative proposals had called for distributed amplifiers or other equally bulky and inefficient methods.

The determination to supply nothing but the best quality workmanship in the end products has been maintained throughout operations. As the activities increased, a full quality control system was installed to implement this determination. Behind this policy is the feeling that a company principally in the field of engineering development can ill afford to risk its reputation as a result of possible defects in workmanship and materials. For this reason only the best materials are used, regardless of customers' requirements.

Corporate Information

Applied Technology stock is entirely held by employees, officers, and directors. As mentioned earlier, stock ownership by employees is encouraged on a sliding scale. Special authorizations to purchase additional shares for key personnel have been made, but no stock option plans or other diluting types of participation have been permitted. To avoid the unfair dilution of the equity of the early arrivals in the corporation, a continual increase in the sale price of the stock has been established even though there is no public market. This increase in price has been scaled both to the length of time of successful operation and to the earnings per share. An attempt has been made to parallel to some degree the price trend of similar stocks in other corporations which have similar records of growth. By following such a plan the founders feel that both the early and the late arrivals will be treated fairly.

The Board of Directors consists of W. E. Ayer, P. D. Strum, C. V. Barker, J. L. Grigsby, W. R. Rambo, O. G. Villard Jr., and F. L. Berry. The officers are W. E. Ayer, president; P. D. Strum, vice president; K. Petty, secretary; and C. V. Barker, treasurer. At monthly meetings the Board of Directors have a close control over company policies and operations.

Sales to date have been about $800,000, and the present sales rate is about $750,000 per year. Estimates indicate a total sales for the coming year of about $1,000,000. Sales of such magnitude by a relatively small company are made possible by a harmonious working relationship with the local banking community and the government agencies with whom prime contracts are held. The goal of substantial long-term earnings is being pursued with careful attention being given to the short-term picture. Annual earnings are now running 32 cents per dollar of par value.

It now appears that the company motto ". . . from concept to reality" has been applied successfully to itself.

FINANCIAL NEWS

VARIAN OFFERS NEW STOCK

The board of directors of Varian Associates, Palo Alto, Cal., has authorized an offering of additional shares of its capital stock to its shareholders by means of stock rights allowing the purchase of one share of stock for each 10 rights held.

One right will be issued for each share of capital stock held on the record date. Subscription price of the new stock will be announced later, along with announcement of the record date and subscription period. The subscription period is expected to last approximately two weeks, after which unexercised rights will become worthless.

Dr. Edward L. Ginzton, chairman of the board, said the offering will be made in a prospectus mailed to all shareholders of record immediately following the record date. Warrants representing the subscription rights and full instructions for their use will be mailed at that time to each shareholder.

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MELPAR ANNOUNCES CONTRACT AWARDS TOTAL

New contracts and additions to current contracts awarded to Melpar, Inc., Falls Church, Va., for the first three months of the year totaled approximately $7.5 million, it has been announced by President Edward M. Bostick.

These include a $1.7 million Navy contract for production of two operational flight trainers for the Douglas A4D-2N weapon system.

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RAYTHEON REPORTS FIRST QUARTER SALES, PROFITS

Sales of Raytheon Company in the first quarter of 1961 totaled $138,158,000 and profits after taxes were $1,365,000. This is equal, after provision for preferred dividends, to 33 cents per share on 3,855,045 shares of common stock. In the first quarter a year ago sales were $134,752,000 and profits after taxes were $2,160,000 or 56 cents a share on the 3,714,418 common shares then outstanding. The provision for Federal and foreign income taxes in the first quarter of 1961 was $1,475,000.

This and other financial data were reported by Charles F. Adams, chairman of the board, at the company's annual meeting. Richard E. Krafve, president, reported on operations and progress to the stockholders.

It was noted that most of the reduction in earnings in the first quarter of this year compared with a year ago resulted from a continuation of lower sales volume in some commercial product and component lines and competitive price-cutting which began in 1960, together with substantially increased expenditures for research and new product development.

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the fifth
Freedom...

sparks advanced electronic R&D at Amherst Laboratories

Creativity can assume infinite form and direction. The ideal formula for creativity has yet to be determined. However, at Amherst Laboratories, progressive leadership in advanced electronic R & D can be attributed to the dynamic stimulus of the Fifth Freedom . . . Freedom of the mind, an essential ingredient in keeping the world free. To some, it is "freedom of thought"..."freedom of investigation"...whatever the title...it is successful at Amherst Laboratories. Results are evidenced in the conclusion of numerous projects and the ever increasing backlog of prime assignments in advanced Ground, Air and Space Communications.

PROFESSIONAL STAFF AND MANAGEMENT OPPORTUNITIES *are unlimited for Physicists, Mathematicians and Electronic Engineers with advanced degrees and creative desire. All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin. You are invited to direct inquiries in confidence to Mr. H. L. Ackerman, Professional Employment,*

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SYLVANIA **ELECTRONIC SYSTEMS**
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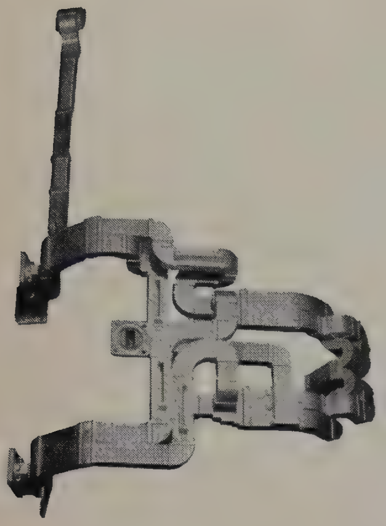
"Shrinking the Universe . . . through Communications"

DIP BRAZING
for fabricating
complex components



Microwave component for Convair, A Division of General Dynamics Corporation. Produced by assembling and dip brazing 109 separate pieces of aluminum extrusions, castings or machined parts. Tolerances are ±.002. Overall length is 13". ASSEMBLED AND DIP BRAZED FOR QUALITY ASSURANCE BY PRECISION DIPBRAZE, INC.

Dip Brazing permits low cost fabrication of complex assemblies made up of numerous individual aluminum extrusions, castings, forgings or machined pieces. The DIP BRAZE method yields greater strength, neater joints, and as there is less distortion or warpage during the brazing process, close tolerances can be maintained.

Complete Dip Brazing Service.

PRECISION DIPBRAZE, INC. provides complete dip brazing services for producing quality assured waveguide assemblies, missile engine components, electronic chassis, heat exchangers, and a wide range of hardware used in the aero-space, ground support, communications and commercial fields. Precision machine shop facilities are maintained to support manufacturing and fabrication services.

Technical assistance on assembly, joint design and brazing is provided.

Write for Technical Bulletin PDI 2

PRECISION DIPBRAZE, INC.

12031 VOSE STREET, NORTH HOLLYWOOD, CALIFORNIA (POplar 4-7236)

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NEW LITERATURE

HUGHES PUBLISHES BROCHURE ON NEW MULTI-MODE TUBE

A brochure describing the operation of the new Multi-Mode Tonotron storage tube developed by Hughes Aircraft Company's vacuum tube products division, Oceanside, Cal., is now available.

The brochure compares the operation of conventional Hughes storage tubes with the Multi-Mode tube which employs bombardment induced conductivity as well as secondary emission effects. The new tube displays high contrast, high resolution stored and nonstored information simultaneously in either dark or light trace modes. It will selectively erase any part of a display.

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MINIATURE VHF-UHF CAVITY AMPLIFIERS DESCRIBED

Resdel Engineering Corp., Pasadena, Cal. announces their new bulletin which describes the Resdel 20 Series of Cavity Amplifiers. These miniature cavity amplifiers are the world's smallest and lightest, and feature coverage from 215-2325 Mc.

The Bulletin includes complete specifications and a curve of output power in db versus temperature.

Circle Reader Service Card 161

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PRECISION RESISTORS DESCRIBED IN PYROFILM CATALOG

A feature article describes the basic differences between wire wound and PyroSeal deposited carbon film resistors in the new 1961 catalog of the Pyrofilm Resistor Co., Parsippany, N. J. As illustrated in the article, this patented PyroSeal process has resulted in the perfection of the most stable carbon film resistor available.

Complete specifications, characteristics, applications and derating curves for Pyrofilm's PT commercial Resistors, Mil Spec Resistors, Hi-Voltage Resistors and High Resistance Resistors are given.

The eight page catalog describes and illustrates Pyrofilm's Micro-Thin Deposited Carbon Film Microwave Resistors for coaxial low and high frequency attenuators and terminations, waveguide attenuators and probes. They are available in Rods, Discs, Rod & Discs, plus custom designs.

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BULLETIN DESCRIBES TRANS-SONICS' CRYOGENIC SENSORS

Trans-Sonics, Inc., Burlington, Mass., offers a new eight page bulletin, #2000, describing its platinum-resistance temperature transducers. Specifically designed for use with cryogenic fluids, such as liquid hydrogen and LOX, the sensors are suitable for airborne or ground based applications.

As described in Technical Bulletin 2000, the temperature transducers may be calibrated in Trans-Sonics' own pressure cryostat against an NBS calibrated reference thermometer. The accuracy of such elements is ±0.1°F at temperatures as low as −435°F. Units containing trimming networks to insure interchangeability to ±0.1°F are also described.

In addition to describing Trans-Sonics' Cryogenic temperature transducers, the bulletin discusses the company's background and facilities. A brief discussion of the International Temperature Scale and its relationship to cryogenic temperature measurement makes the bulletin of technical interest.

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HEWLETT-PACKARD PUBLISHES NEW APPLICATION NOTE

A two-page application note now available from Hewlett-Packard Co., Palo Alto, Cal., describes a simple modification to adapt a Hewlett-Packard X-band or H-band crystal detector mount for use as an inexpensive mixer for a laboratory receiver.

The Application Note, No. 51 describes and illustrates the modification in detail and shows how the detector can be used in a complete receiver arrangement. The modification itself involves replacing the instrument's brass contact guide with an equivalent plastic insert. The instruments involved are the models X485B and H485B Crystal Detector Mounts.

The note also includes complete instructions for using a model 340B or 342A Noise Figure Meter to adjust the modified detector mount and other receiver components for minimum noise.

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1961 POWER SUPPLY CATALOG, HANDBOOK NOW AVAILABLE

A new DC Power Supply Catalog and Handbook is now available from Dressen-Barnes Electronics Corp., Pasadena, Cal., to anyone interested in dc power design or procurement.

The 24 page manual includes a step by step procedure designed for engineers who wish to calculate packaging dimensions for multiple dc outputs. Considerations include spacing problems for modular dc power supplies under various conditions of ambient temperature, external cooling and rated current. The catalog details over 200 power supplies plus 1,000,000 combinations of kitted modules.

Circle Reader Service Card 165

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ANTENNA SYSTEMS RELEASES COMPANY BROCHURE

Antenna Systems, Inc., Hingham, Mass. has released a company brochure which contains a capsule history of the company and a brief description of its various types of antenna and antenna components.

The brochure is documented by pictures of company products, personnel, and facilities.

Circle Reader Service Card 166

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HEWLETT-PACKARD 1961 CATALOG NOW AVAILABLE

The 1961 Hewlett-Packard catalog of electronic test instruments is now available. This 220 page catalog contains complete listings, descriptions and specifications of the more than 400 test instruments offered by Hewlett-Packard Co., Palo Alto, Cal. It also includes a 16 page descriptive listing of the special systems and instrumentation produced by the company's Dymec Division.

Instruments are grouped by type or function in the body of the catalog. Each group is preceded by "Application Data" pages which summarize the equipment offered and discuss latest measuring techniques. The equipment groups include oscilloscopes; oscillators; power supplies and audio, square wave, pulse and digital delay generators; wave and distortion analyzers; ac and dc voltmeters, ammeters and ohmmeters; amplifiers; frequency and time measurement equipment; primary frequency and time standards; signal generators; microwave equipment, and Dymec systems and instruments. The microwave section is further divided into power measurement, impedance measurement, noise figure measurement, and other microwave equipment.

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ANTENNA SYSTEMS OFFERS SPEC SHEET ON REFLECTORS

Antenna Systems, Inc., Hingham, Mass., has released a catalog sheet on its line of spun parabolic reflectors. It contains specifications on the outside diameter, effective diameter, focal length, f/d ratio, maximum depth, bead diameter, flange width, material, thickness, center hole diameter, net weight, shipping weight, and surface tolerance for dishes from four inches to 10 feet.

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CATALOG FROM PRODELIN DESCRIBES COAXIAL TRANSMISSION LINES

A forty page, fully illustrated, new issue of Catalog 595 by Prodelin, Inc., Kearny, N. J., describes reactance-compensated rigid '800' aluminum and copper coaxial transmission lines.

The catalog includes new large diameter Spir-O-lok connectors, standard EIA type flanges, supporting hardware and dehydration accessories, incorporates installation procedures and recommendations, and provides valuable engineering guidance data on VSWR, attenuation, power and efficiency.

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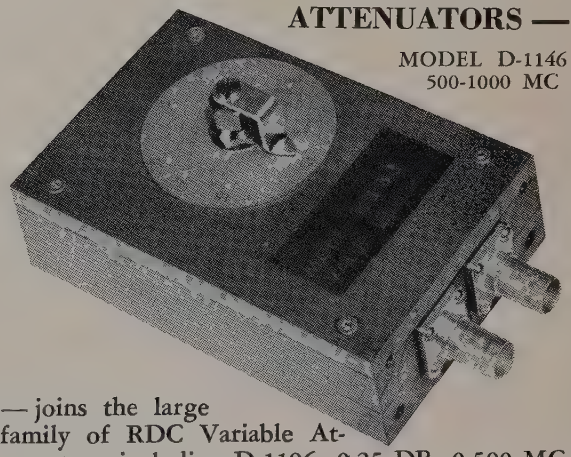

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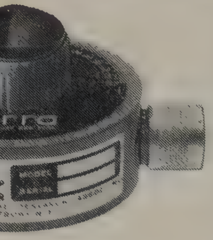

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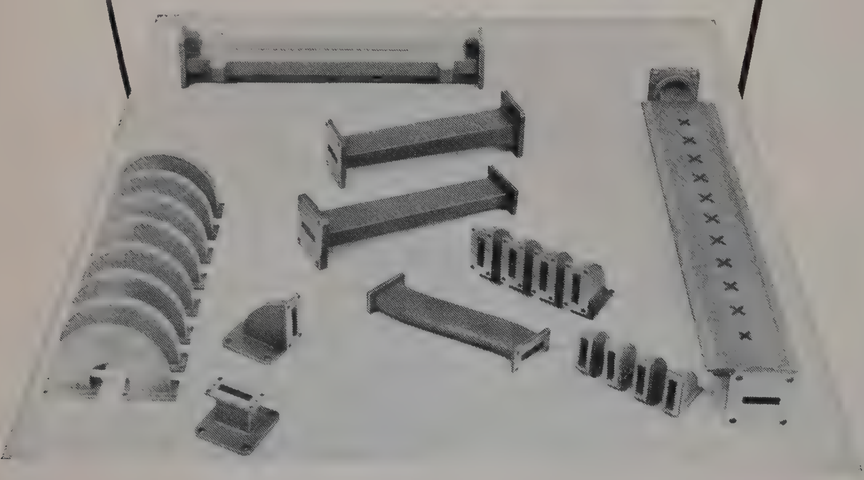

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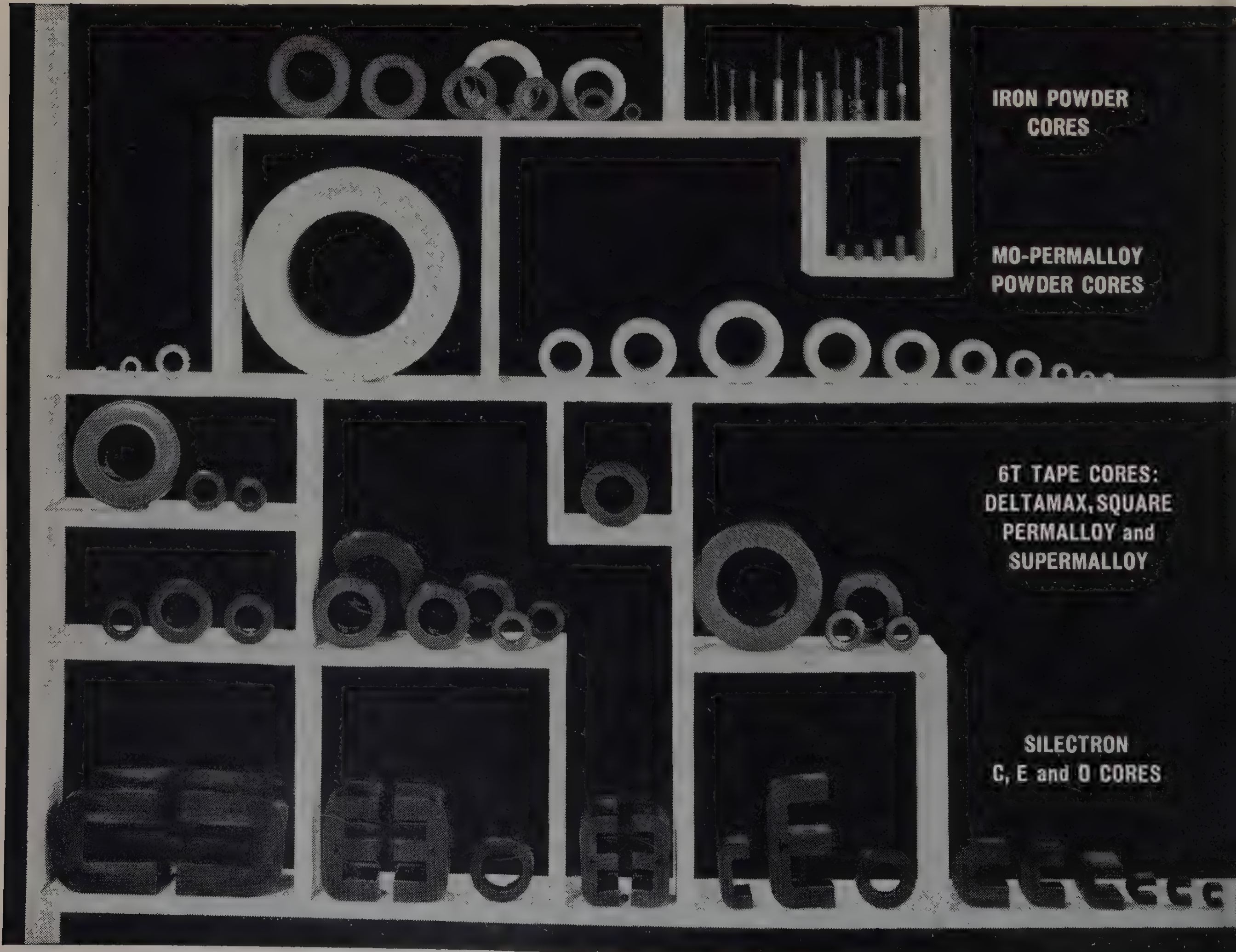
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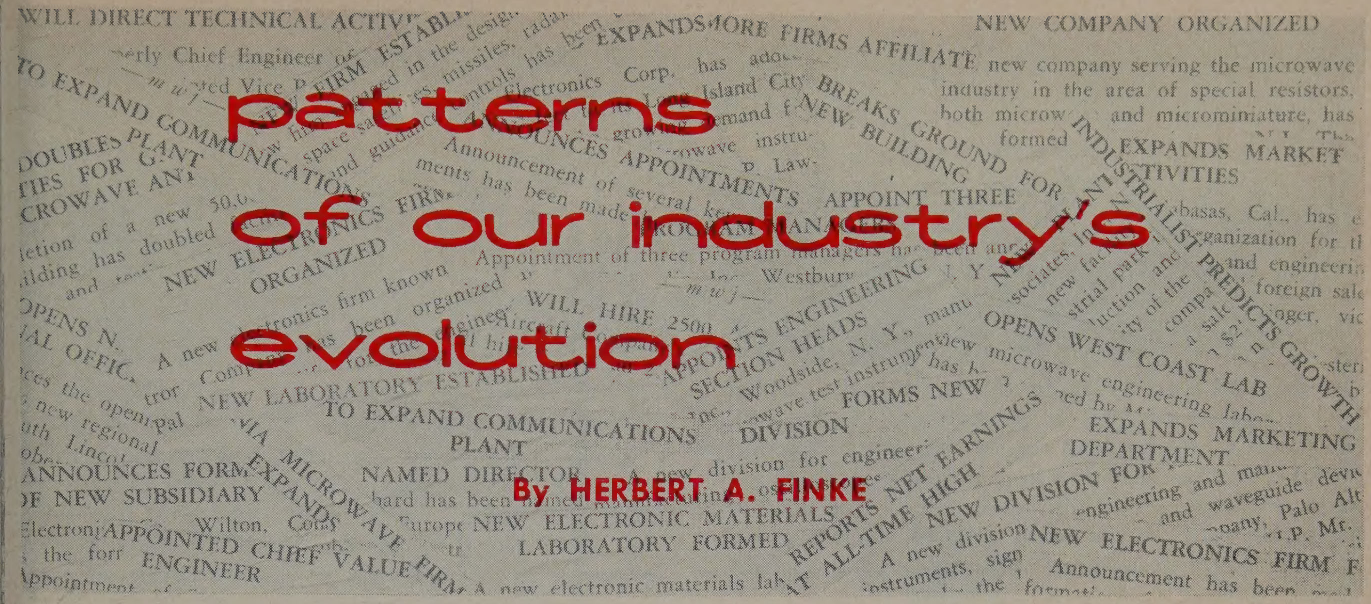

patterns of our industry's evolution

By HERBERT A. FINKE

During the past two decades hundreds of new electronic companies have appeared. The old giant companies are still on the scene; a few new giants have developed; but the ranks of small and medium-sized companies have experienced prolific, mushrooming growth. One is tempted to inquire "Is the growth prolific or profligate? Are there too many electronic companies cluttering up the industry?"

Year after year, more and more companies manufacture almost identical products. Each succeeding trade show confirms the ever increasing duplication by competitive organizations. In the average small or medium-sized company the talents of superior engineers are, all too often, used to re-design old products with the emphasis on cutting costs. There is little opportunity for these men to work on new ideas because the pressure of competition results in a struggle for sheer existence.

It must be admitted that some of the dignity of scientific development is vanishing in the melee of old and new companies battling for economic survival. Designing a revolutionary product, with a whole new scope of adaptation, may still be the dream of many young engineers. The dream takes second place, however, to the problem of coping with minor price cuts and improvements of competing firms. Cost control and cost consciousness are essential ingredients in the operation of a profitable business, but the engineering talent required to work out minute reductions in price can often be put to better use.

It is interesting to analyze the forces which have resulted in the formation of so many new concerns. There is powerful incentive today for a talented engineer to spin-off from his present employer. The decline of professional prestige, which the working engineer has experienced, spurs him toward management with its ostensibly greater financial rewards and higher social status. Disillusionment sets in, however, as soon as the newly created manager pays federal and state income taxes on his newly inflated salary. He now realizes that in order to achieve a modicum of financial security he must become part of a capital gain situation. The more sophisticated engineer may recognize this situation sufficiently early in his career to circumvent the management stage, and become an entrepreneur immediately.

The classic pattern in the formation of a new electronics company is simple. A nucleus of people who have acquired competence in a specific product field decide to exploit this competence as entrepreneurs. The investing public is willing to buy in, to provide the required capital. The unusually inflated price-earnings ratios of such speculations promise huge returns to the investors. There can be no quarrel with this procedure, for it is in the great tradition of American enterprise and the free market.

Present day purchasing practices place inordinate emphasis on price, affording ample opportunity for a new, low cost outfit to break into a proprietary field by

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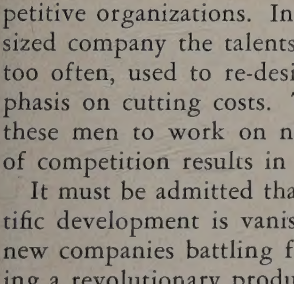

HERBERT A. FINKE was graduated from M.I.T. in 1939 with a BEE and received the MEE degree from Brooklyn Polytechnic Institute in 1948. From 1939-1941 Mr. Finke was associated with the United Aircraft Corp., serving as administrative assistant to the chief engineer.

In 1941 he joined the RCA Princeton Laboratories as research engineer on vacuum tube design. He invented the coaxial line noise diode and contributed to the development of electron beam deflection devices. He participated in flight testing of LORAN and SHORAN in New York city during the war.

Mr. Finke transferred to PRD as director of engineering and became general manager in 1957. Last year he joined Varian Associates as Director of Long-Range Product Planning and in February, 1961, he was named Vice President and General Manager of Bomac, subsidiary of Varian.

He is a member of Sigma Xi, Pi Mu Epsilon, the AMA and the IRE.

minor modification of an existing product. This, too, is in the tradition of American enterprise.

Our whole economy is based on the principle of more efficient mass production to reduce costs and prices. Recent court decisions, concerning alleged price-fixing in the industry, have been extremely harsh and leave no doubt as to the strength of the anti-trust laws.

There is danger to the industry, however, in the number of new companies which contribute nothing new or distinctive to the art, but merely copy the designs of others with minor changes. These companies do not have research and development costs to meet, and they are able to depress the market price so that profits become marginal or non-existent. As the market becomes saturated the copiers may find it impossible to survive because they have no regenerative power and have acquired no skill in new fields. The old line companies will already have suffered, however, and some of them may never recover. In a war of attrition nobody wins.

It is important to recognize the role assumed by a segment of the financial community in manipulating the formation of new companies as purely financial tools. Nondescript organizations have been catapulted into public ownership by speculators, who withdraw as quickly as possible after profit taking. Too often the company collapses, leaving the stunted careers of the participants in its wake.

The economic forces, which have catalyzed the formation of so many electronic companies in recent years, will probably continue, and we can expect to see many new spin-offs in the coming decade. Perhaps there are losses in manpower utilization and scientific prestige. Can the evolutionary process of natural selection be suppressed in industry any more than in the biological life cycle? Every mature industry becomes highly competitive and marginal operators are eliminated.

The demise of the old and the birth of the new are rarely accomplished without casualties. It must be recognized that not all of the old line companies are worthy of continued existence, while many of the new companies are destined to become the respected suppliers of the future. No company can rest upon its laurels and ignore the corrosive effects of mismanagement, poor direction, and discontent. Key people must be adequately rewarded and a climate of progressive leadership must be created.

Even the most hard-headed proponent of "laissez-faire" will not favor the complete abandonment of all ethical principles. A particular case in point is the obvious need for defining the rights of the engineer, in contradistinction to the rights of his employer. Industry practice credits the engineer with "owning" the knowledge and ability acquired on the job, but he does not own the specialized design data to construct his company's products. Design data represents substantial capital investment and is legally company property.

There is significant difference between using one's knowledge to manufacture a carbon copy of someone else's product, and using this knowledge to produce a new and better product. Existing patent laws attempt to protect against infringement but are hardly adequate to cover proprietary, albeit unpatentable, design information.

Outright reproduction of a design is not favorably regarded by the more reputable companies. At the least they will make some contribution in re-design, be it even a minor one. With proper respect for the difference between competition and larceny new companies can be a source of rejuvenation. Under such circumstances the race is to the swift, and may the best team win.

The electronics industry has been experiencing a rising market for years, and there is valid reason to believe this market will continue in the foreseeable future. The phenomenal ability to create new products, with new functions, can extend the limits of growth to a veritable Ultima Thule.

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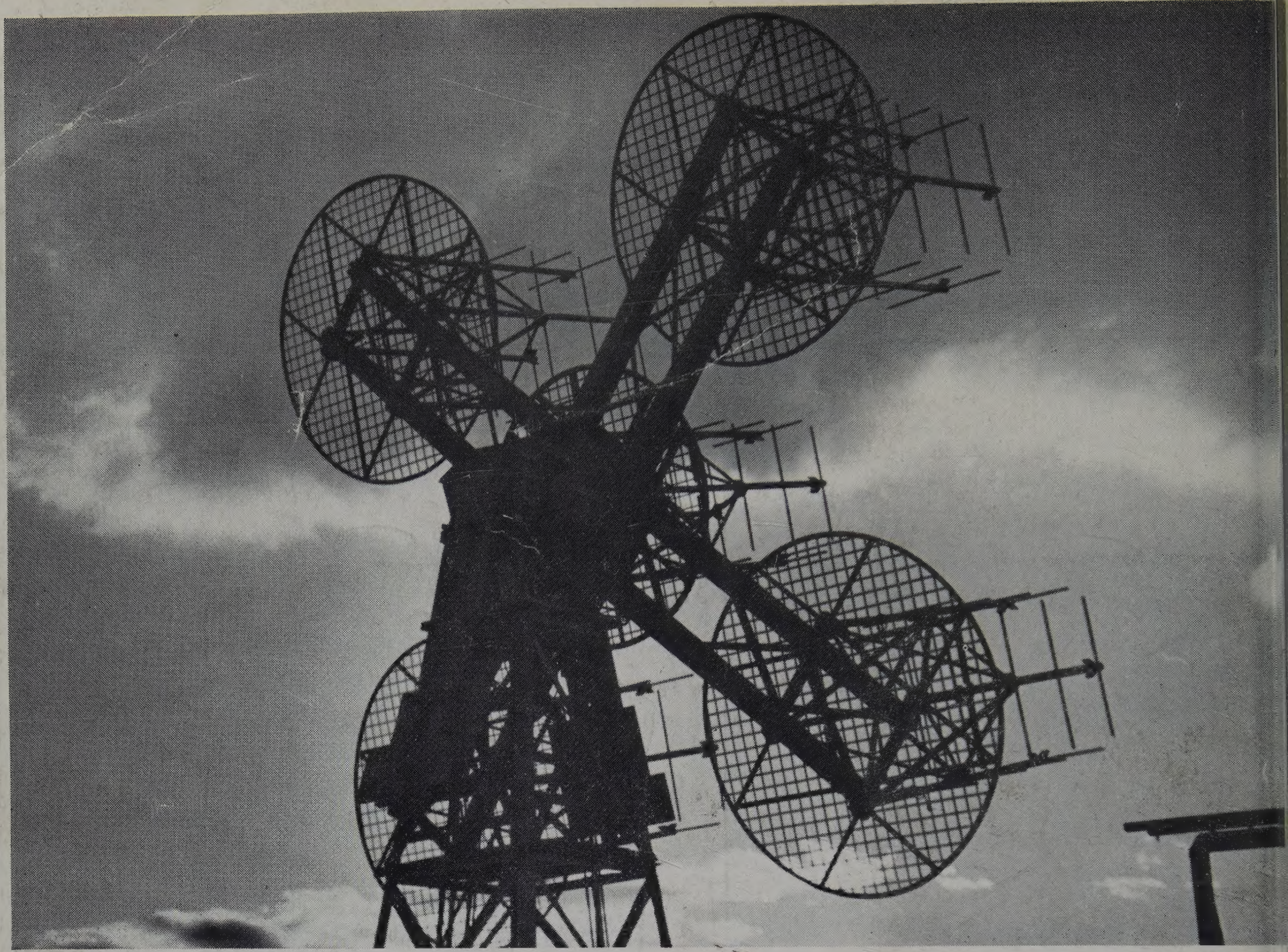

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The Kennedy Model 1142 WHF Yagi Automatic Tracking and Telemetering Antenna offers greater flexibility than can presently be obtained with other similar units. As a transmitter or receiver, it may be linear cross-polarized simultaneously or circular polarized in a clockwise or counter-clockwise pattern by pushbutton remote control. As a receiver, with selected preamplifiers the sum or difference patterns can be achieved simultaneously, affording better tracking control.

SPECIFICATIONS

	RECEIVING	TRANSMITTING (Optional)
	4 Yagi sub-arrays, cross polarized, constructed in a square $\frac{3\lambda}{4}$ center to center	1 Yagi sub-array, cross polarized, constructe in the center of the 4 receiving Yagi sub-arrays
POLARIZATION	Cross-polarized simultaneously (sum or difference pattern) or clockwise or counterclockwise by pushbutton remote control.	Cross-polarized simultaneously or clockwis or counterclockwise by pushbutton remot control.
Note:	With proper preamplifiers the sum or difference patterns can be achieved simultaneously.	
BANDWIDTH	8%	8%
VSWR	1.1 to 1.0 or better at center frequency. 2.0 to 1.0 or better for 8% band.	1.1 to 1.0 or better at center frequency. 2.0 to 1.0 or better for 8% band.
ISOLATION (cross polarization)	30 db or better	30 db or better
GAIN	21 db or better over isotropic sources.	14 db or better over isotropic sources.
CIRCULARITY	±1 db	±1 db
ERROR SIGNAL (difference pattern)	—30 db or better	———
HALF POWER ANGLE (center frequency)	18° or better in E and H plane.	41° or better in E and H plane.
SIDELOBE LEVEL (sum pattern)	—10.5 db	—18 db
FRONT TO BACK RATIO	—18 db	—18 db
CONNECTORS	Type N	Type N
POWER (RG-9A/U)	———	400 to 700 watts depending on frequency.

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